IST Laboratory Handbook

MULTIPLICATION FACTORS AND THEIR PREFIXES

Multiplication factor			Prefix	Symbol
1 000 000 000 000 000 000	=	10^{18}	exa	E
1 000 000 000 000 000	=	10^{15}	peta	P
1 000000000000	=	10^{12}	tera	T
1000000000	=	10^{9}	giga	G
1 000000	=	10^{6}	mega	M
1 000	=	10^{3}	kilo	k
100	=	10^{2}	hecto	h
10	=	10^{1}	deca	da
0.1	=	10^{-1}	deci	d
0.01	=	10^{-2}	centi	c
0.001	=	10^{-3}	milli	m
0.000 001	=	10^{-6}	micro	μ
0.000 000001	=	10^{-9}	nano	n
0.000 000 000 001	=	10^{-12}	pico	p
0.000 000 000 000 001	=	10^{-15}	femto	f
0.000 000 000 000 000 001	=	10^{-18}	atto	a

1 centimetre	= 10 millimetres	
1 decimetre	= 10 centimetres	
1 metre	= 10 decimetres	
1 decametre	= 10 metres	
1 hectometre	= 10 decametres	= 100 metres
1 kilometre	= 10 hectometres	= 1000 metres

TEMPERATURE CONVERSION CHART

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-18	-0.4	4	39.2	26	78.8	48	118.4	70	158.0	92	197.6
-17	1.4	5	41.0	27	80.6	49	120.2	71	159.8	93	199.4
-16	3.2	6	42.8	28	82.4	50	122.0	72	161.6	94	201.2
-15	5.0	7	44.6	29	84.2	51	123.8	73	163.4	95	203.0
-14	6.8	8	46.4	30	86.0	52	125.6	74	165.2	96	204.8
-13	8.6	9	48.2	31	87.8	53	127.4	75	167.0	97	206.6
-12	10.4	10	50.0	32	89.6	54	129.2	76	168.8	98	208.4
-11	12.2	11	51.8	33	91.4	55	131.0	77	170.6	99	210.2
-10	14.0	12	53.6	34	93.2	56	132.8	78	172.4	100	212.0
-9	15.8	13	55.4	35	95.0	57	134.6	79	174.2	101	213.8
-8	17.6	14	57.2	36	96.8	58	136.4	80	176.0	102	215.6
-7	19.4	15	59.0	37	98.6	59	138.2	81	177.8	103	217.4
-6	21.2	16	60.8	38	100.4	60	140.0	82	179.6	104	219.2
-5	23.0	17	62.6	39	102.2	61	141.8	83	181.4	105	221.0
-4	24.8	18	64.4	40	104.0	62	143.6	84	183.2	106	222.8
-3	26.6	19	66.2	41	105.8	63	145.4	85	185.0	107	224.6
-2	28.4	20	68.0	42	107.6	64	147.2	86	186.8	108	226.4
-1	30.2	21	69.8	43	109.4	65	149.0	87	188.6	109	228.2
0	32.0	22	71.6	44	111.2	66	150.8	88	190.4	110	230.0
1	33.8	23	73.4	45	113.0	67	152.6	89	192.2	111	231.8
2	35.6	24	75.2	46	114.8	68	154.4	90	194.0	112	233.6
3	37.4	25	77.0	47	116.6	69	156.2	91	195.8	113	235.4

Formulae

Celsius to Fahr: Multiply by 9, divide the product by 5 and add 32

Fahr. to Celsius: Subtract 32, multiply by 5 and divide by 9.

Fahrenheit temperatures below °F and Celsius temperatures below 00 will be negative numbers.

PHYSICAL QUANTITIES WITH SI AND OTHER PREFERRED UNITS

Physical Quantities	Symbols	Preferred Units	
Length	I	metre	m
Wavelength Of Light	λ Greek lambda	nanometre	nm
Area	A	square metre	m^2
Volume	V	cubic metre	m^3
Capacity	V	millilitre	ml
Time	t	second	s
Frequency	f	hertz (formerly cycle per second)	Hz
Velocity	v	metre per second	ms^{-1}
Gravitational acceleration	g	metre per second^2	ms^{-2}
(Gravitational field strength at earths surface)	g	newton per kg	$N\ kg^{-1}$
Mass	m	kilogram tonne (1000kg)	kg t
Density	ρ Greek rho	kilogramme per m^3	$kg\ m^{-3}$
Moment of Inertia	I,J	kilogramme metre^2	$kg\ m^2$
Force	F	newton	N
Torque	T	newton metre	N m
Pressure	P	pascal (formerly Newton per m^2)	Pa $N\ m^{-2}$
Youngs modulus of elasticity	E	newton per metre^2	$N\ m^{-2}$
Dynamic viscosity	ή Greek eta	newton second per m^2	$Ns\ m^{-2}$
Surface Tension	y Greek gamma	newton per metre	$N\ m^{-1}$
Work or energy	W	joule or newton metre or watt second	J
Molar volume	Vo	cubic metre per kilomole	m^3 $kmol^{-1}$
Thermodynamic temperature T		kelvin	K
Temperature value	θ Greek theta	degree Celsius watt per	°C
Thermal Conductivity	κ Greek kappa	watt per metre Kelvin	$W\ m\ k^{-1}$
Electrical current	I	ampere	A
Quantity of electricity	Q	ampere hour coulomb (ampere sec)	A h C
Electromotive force	E	volt	V
Potential difference	V		
Resistance	R	ohm	Ω
Reactance	X		
Impedance	Z		
Conductance	G	siemen	S
Resistivity	ρ Greek rho	ohm metre	$Vm\ A^{-1}$
Conductivity	ς Greek sigma	siemen per metre	$S\ m^{-1}$
Magnetic Field Quantity	B	tesla (formerly weber per m^2)	T
Magnetomotive force	F	ampere-turn	A t
Magnetic field quantity	H	ampere per metre	$A\ m^{-1}$
Self inductance	L	henry	H
Mutual inductance	M		
Capacitance	C	microfarad	μF
Luminous intensity	I	candela	cd
Illumination	E	lux (formerly lumen per m^2)	lx
Luminance	L	candela per m^2	$Cd\ m^{-2}$

PHYSICAL QUANTITIES WITH SI AND OTHER PREFERRED UNITS (cont'd)

Some notes on the use of indices

It is normal practice to write	1/10	=	10^{-1}		
Similarly	1/100	=	$1/10^2$	=	10^{-2}
	m/s	=	m x 1/s	=	m s^{-1}
	kg/m^3	=	kg x $1/m^3$	=	kg m^{-3}
	Ns/m^2	=	Ns x $1/m^2$	=	Ns m^{-2}

Some notes on the presentation of units

The combination of a prefix and a symbol for a unit is regarded as a single symbol and should be written with no space between the prefix and the unit: for example cm and not c m.

When writing the symbol for a derived unit formed from several basic units, the universal symbols should be separated by a space; for example the unit for velocity, metre per second, is written m s^{-1} and not ms^{-1} (ms would be a millisecond).

When a unit is raised to a power, the power refers only to the unit and not to any number preceding it; for example 2.3 cm^3 is 2.3 x 1 cm^3.

In any number where the decimal point is placed before the first digit of the number, a zero should always be placed before the decimal point for example 0.251 and not .251.

COMMON CONVERSIONS AND CONSTANTS

MAIN METRIC CONVERSIONS

Measurement	To Convert:	Multiply by: (Unless otherwise stated)		To give equivalent in:
Area	cm^2	1.5500	$x10^{-1}$	in^2
	m^2	1.0764	x10	ft^2
		1.1960		yd^2
	are	1.1960	$x10^2$	yd^2
		2.4711	$x10^{-1}$	ac
		1.0000	$x10^2$	m^2
	ha	2.4711		ac
		1.0000	$x10^4$	m^2
		1.0000	$x10^{-2}$	km^2
	km^2	2.4711	$x10^2$	ac
		3.8610	$x10^{-1}$	mi^2
		1.0000	$x10^2$	ha
Length	µm	10^{-6}		m
	cm	3.9370	$x10^{-1}$	in
		3.2808	$x10^{-2}$	ft
	m	3.9370	x10	in
		3.2808		ft
		1.0936		yd
	km	6.2137	$x10^{-1}$	mi
Mass	g	3.5274	$x10^{-2}$	oz
	kg	2.2046		lb
		1.0000	$x10^{-2}$	quintals
	quintal	1.0000	$x10^2$	kg
		1.0000	$x10^{-1}$	t
	t	2.2046	$x10^{-3}$	lb
		9.8421	$x10^{-1}$	imperial tons (long tons)
		1.1023		US tons (short tons)
		1.0000	$x10^3$	kg
Power	W	7.3756	$x10^{-1}$	ft lbf s^{-1}
		1.3410	$x10^{-3}$	hp (UK)
	hp (metric)	9.8632	$x10^{-1}$	hp (UK)
Pressure	cm (head of water)	1.03	$x10^3$	lbf in^2 (psi)
		9.703	$x10^{-4}$	atmospheres (atm)
		1.002	$x10^{-3}$	kgf cm^{-2}
		9.833	$x10^{-4}$	bar
		9.8	$x10^{-2}$	kPa
	mm (head of Hg)	3.9370	$x10^{-2}$	in (head of Hg)
		1.3332	$x10^{-3}$	kPa
		1.3332	$x10^{-5}$	bar
	kPa (also kN m^{-2})	1.4504	$x10^{-1}$	lbf in^{-2} (psi)
		2.0885	x10	lbf ft^{-2}
		2.953	$x10^{-4}$	in (head of Hg)
		1.000	$x10^{-2}$	bar
	kgf cm^{-2}	1.4223	x10	lbf in^{-2} (psi)
		9.678	$x10^{-1}$	atmosphere (atm)
		9.39	$x10^{-4}$	cm (head of water)
		9.804	$x10^{-1}$	bar
		1.4504	x10	lbf in^{-2} (psi)
		9.8693	$x10^{-1}$	atmosphere (atm)
		2.953	x10	in (head of Hg)
		1.017	$x10^3$	cm (head of water)
		1.020		kgf cm^{-2}

COMMON CONVERSIONS AND CONSTANTS (cont'd)

MAIN METRIC CONVERSIONS

Temperature	°C	x by 9/5 and then add 32		°F
	K	subtract 273.2		°C
Velocity	cm h^{-1}	9.110	$x10^{-5}$	ft s^{-1} (fps)
		2.778	$x10^{-5}$	m s^{-1}
		2.400	$x10^{-1}$	m day^{-1}
	m s^{-1}	3.2808		ft s^{-1} (fps)
		2.237		ml h^{-1} (mph)
		3.6000	$x10^{4}$	cm h^{-1}
		8.6400	$x10^{3}$	m day^{-1}
		3.6000		km h^{-1}
	m day^{-1}	3.796	$x10^{-4}$	ft s^{-1} (fps)
		1.157	$x10^{-1}$	m s^{-1}
		4.1667		cm h^{-1}
	km h^{-1}	9.113	$x10^{-1}$	ft s^{-1} (fps)
		6.2137	$x10^{-1}$	ml h^{-1} (mph)
		2.778	$x10^{-1}$	m s^{-1}

COMMON CONVERSIONS AND CONSTANTS

MAIN IMPERIAL CONVERSIONS

Measurement	To convert:	Multiply by: (unless otherwise stated)		To give equivalent in:
Area	in^2	6.4516		cm^2
	ft^2	9.2903	$x10^2$	cm^2
	yd^2	8.3613	$x10^{-1}$	m^2
		9.0000		ft^2
	ac	4.0469	$x10^3$	m^2
		4.0469	$x10^{-1}$	ha
		4.8400	$x10^3$	yd^2
	mi^2	2.5900	$x10^2$	ha
		2.5900		km^2
		6.4000	$x10^2$	ac
Length	in	2.5400		cm
	ft	3.0480	x10	cm
		1.2000	x10	in
	yd	9.144	$x10^{-1}$	m
		3000		ft
	mi	1.6093		km
		5.280	$x10^3$	ft
		1.760	$x10^3$	yd
Mass	grain	6.47989	$x10^{-5}$	kg
	oz	2.8349	x10	g
	lb	4.5359	$x10^{-1}$	kg
	cwt	5.08023	x10	kg
	imperial ton	1.0160	$x10^3$	kg
	(long ton)	1.0160		t
		2.2400	$x10^3$	lb
	US ton	9.07 18	$x10^2$	kg
	(short ton)	9.0718	$x10^{-1}$	t
		2.0000	$x10^3$	lb
Power	ft lbf s^{-1}	1.3558		w
	hp (UK)	7.4570	$x10^2$	w
		1.0139		hp (metric)
Pressure	Ibf in^{-2} (psi)	7.031	$x10^{-2}$	kgf cm^{-2}
		6.8948		kPa (or kN m^{-2})
		6.8948	$x10^{-2}$	bars
		9.71	$x10^{-4}$	cm (head of water)
		6.806	$x10^2$	atmospheres (atm)
	atmosphere	1.030	$x10^3$	cm (head of water)
	(atm)	1.013		bars
		1.033		kgf cm^{-2}
		1.4693	x i0^3	lbf in^{-2} (psi)
	in (head of Hg)	3.386	$x10^{-2}$	bar
Temperature	°F	subtract 32 then x by 5/9		°C
Velocity	in s^{-1}	2.54	$x10^2$	m s^{-2}
	ft s^{-1} (fps)	1.0973	$x10^4$	cm h^{-1}
		3.048	$x10^{-1}$	m s^{-1}
		2.6335	$x10^2$	m day^{-1}
		1.0973	$x10^{-1}$	km h^{-1}
		6.818	$x10^{-1}$	mi h^{-1}
	ft min^{-1}	5.03	$x10^{-3}$	m s^{-1}
	knots (UK)	5.14773	$x10^{-1}$	m s^{-1}
			x101	m s~^{1}

CONVERSION CHART

To convert into SI units multiply by the given factor
To convert SI into English/Metric divide by the factor

Length (metre) m		
in	2.54	$x10^{-2}$
ft	3.048	$x10^{-1}$
yd	9.144	$x10^{-1}$
mile	1.60934	$x10^{3}$
Angstrom		10^{-10}
micron		10^{-6}
mm		10^{-3}
cm		10^{-2}

Area (metre^2) m^2		
in^2	6.4516	$x10^{2}$
ft^2	9.29030	$x10^{2}$
yd^2	8.36127	$x10^{-1}$
acre	4.04686	$x10^{3}$
$mile^2$	2.58999	$x10^{6}$
mm^2		10^{-6}
cm^2		10^{-4}
dm^2		10^{-2}
km^2		10^{6}

Volume (metre^3) m^3		
in^3	1.63871	$x10^{-5}$
ft^3	2.83168	$x10^{-2}$
yd^3	7.64555	$x10^{-1}$
gal (UK)	4.54608	$x10^{-3}$
gal (US)	3.78543	$x10^{-3}$
barrel (US)	1.58988	$x10^{-1}$
mm^3		10^{-9}
cm^3		10^{-6}
dm^3		$x10^{-3}$
litre	1.00003	$x10^{-3}$

Mass (kilogram) kg		
grain	6.47989	$x10^{-5}$
oz	2.83495	$x10^{-2}$
lb	4.53592	$x10^{-1}$
cwt	5.08023	x10
ton (UK long)	1.01605	$x10^{3}$
ton (US long)	9.07185	$x10^{2}$
µg		10^{-9}
mg		10^{-6}
g		10^{-3}
tonne metric)		10^{3}

Velocity m s^{-1}		
in s^{-1}	2.54	$x10^{-2}$
ft s^{-1}	3.048	$x10^{-1}$
ft min^{-1}	5.08	$x10^{-3}$
mph	4.4704	$x10^{-1}$
knots (UK)	5.14773	$x10^{-1}$
cm s^{-1}		$x10^{-2}$
km h^{-1}	2.77778	$x10^{-1}$

Acceleration m s^{-2}		
ft s^{-2}	3.048	$x10^{-1}$
cm^2		10^{-2}

Flow (volume) m^3 s^{-1}		
ft^3 s^{-1}	2.83168	$x10^{-2}$
cfm	4.71947	$x10^{-4}$
gal s^{-1}	4.54609	$x10^{-3}$
gal h^{-1}	1.26280	$x10^{-8}$
litre s^{-1}	1.00003	$x10^{-3}$
litre h^{-1}	2.77786	$x10^{-7}$
m^3 min^{-1}	66667	$x10^{-2}$
m^3 h^{-1}	2.77778	$x10^{-4}$

Flow (mass) kg s^{-1}		
lb s^{-1}	4.53592	$x10^{-1}$
lb h^{-1}	1.25998	$x10^{-4}$
ton h^{-1}	2.82236	$x10^{-1}$
kg h^{-1}	2.77778	$x10^{-4}$

Density kg m^{-3}		
grain ft^{-3}	2.8835	$x10^{-3}$
grain m^{-3}	6.47989	$x10^{-5}$
lb in^{-3}	2.76799	$x10^{4}$
lb ft^{-3}	1.601 85	x10
lb gal^{-1}	9.97763	x10
ton yd^{-3}	1.32894	$x10^{3}$
g cm^{-3}		10^{3}
g $litre^{-1}$	9.99972	$x10^{-1}$
g m^{-3}		10^{-3}

CONVERSION CHART (cont'd)

Force (Newton) N kg m s^{-2}		
lb force	4.44822	
dyne		10^{-5}
gm force	9.80665	$x10^{-3}$
kg force	9.80665	
joule cm^{-1}		10^{2}

Pressure in Pascal (Pa) kg m^{-1} s^{-2} N m^{-2}		
in water	2.49089	$x10^{-2}$
ft water	2.98907	$x10^{3}$
in Hg	3.38639	$x10^{3}$
psi (Ibf m^{-2})	6.89476	$x10^{3}$
tbf ft^{-2}	4.78803	10
ton ft in^{-2}	1.54443	$x10^{7}$
ton ft^{-2}	1.07252	$x10^{5}$
poundal in^{-2}	2.14296	$x10^{2}$
poundal ft^{-2}	1.48816	
mm water (kgf m^{-2})	9.80665	
cm water	9.80665	X10
mm Hg (torr)	1.33322	$x10^{2}$
cm Hg	1.33322	$x10^{3}$
dyne cm^{-1}		10^{-1}
atmosphere	1.01325	$x10^{5}$
millibar		10^{2}
bar		10^{5}
Newton mm^{-2}		10^{6}
Newton cm^{-2}		10^{4}

Power or Heat Flow Rate in Watt kg m^2s^{-3} or Js^{-1}		
ft lbf s^{-1}	1.35582	
hp	7.45700	$x10^{2}$
Btu h^{-1}	2.93071	$x10^{-1}$
metric hp	7.35499	$x10^{2}$
kcal h^{-1}	1.163	

Energy or Work or Torque Joule kg m^2s^{-2} N m W s		
ft lbf	1.35582	
ft poundal	4.21401	$x10^{-2}$
hp h	2.68452	$x10^{6}$
Btu	1.05506	$x10^{3}$
therm	1.05506	$x10^{8}$
CHU	1.89910	$x10^{3}$
cal	4.1868	

Energy or Work or Torque (cont'd)		
kcal	4.1868	$x10^{3}$
cal (15°C)	4.1855	
cal (thermochem)	4.184	
litre atm	1.01328	$x10^{2}$
kWh	3.6	$x10^{6}$
erg		10^{-7}
electron-volt	1.602	$x10^{-19}$
lbf ft	1.35582	
gf cm	9.80665	$x10^{-5}$
kgf m	9.80665	
dyne cm		$x10^{-7}$

Viscocity (dynamic) kg m^{-1} s		
lb ft^{-1} s^{-1}	1.48816	
lb ft^{-1} h^{-1}	4.13378	$x10^{-4}$
centipoise		10^{-3}
poise		10^{-1}

Viscocity (kinematic) m^2 s^{-1}		
ft^2 s^{-1}	9.29030	$x10^{-2}$
ft^2 h^{-1}	2.58054	$x10^{-5}$
cm^2 s^{-1}		10^{-4}
centistokes		10^{-6}
Stoke		10^{-4}
m^{-2} h^{-1}	2.77778	$x10^{-4}$

Calorific Value (mass basis) in J kg^{-1} m^2 s^{-2}		
Btu lb^{-1}	2.326	$x10^{3}$
cal g^{-1}	4.1868	$x10^{3}$
kcal kg^{-1}	4.1868	$x10^{3}$

Calorific Value (volume basis) in J m^{-3} kg m^{-1} s^{-2}		
Btu ft^3	3.72589	$x10^{4}$
kcal m^3	4.1868	$x10^{3}$

Surface Tension in J m^{-2} kg s^{-2} Nm^{-1}		
dyne cm^{-1}		10^{-3}
erg cm^{-2}		10^{-3}

CONSTANTS and VALUES

Densities	
Alcohol	800 kg m^{-3}
Paraffin	800 kg m^{-3}
Water	1000 kg m^{-3}
Brine	1200 kg m^{-3}
Sea Water	1250 kg m^{-3}
Mercury	13600 kg m^{-3}
Linear Expansivities	
Steel	10 x 10^{-5}
Iron	12 x 10^{-5}
Copper	17 x 10^{-5}
Brass	18 x 10^{-5}
Specific Latent Heats	
Fusion of Ice	340000 J kg^{-1}
Vaporisation of Water	2250000 J kg^{-1}
Electrochemical Equivalents	
Hydrogen	11 x 10^{-8} kg K^{-1}
Nickel	30 x 10^{-7} kg K^{-1}
Copper	33 x 10^{-7} kg K^{-1}
Silver	112 x 10^{-6} kg K^{-1}
Specific Heat Capacities	
Brass	380 J kg^{-1} K^{-1}
Copper	380 J kg^{-1} K^{-1}
Iron	460 J kg^{-1} K^{-1}
Aluminium	880 J kg^{-1} K^{-1}
Ice	2100 J kg^{-1} K^{-1}
Paraffin	2200 J kg^{-1} K^{-1}
Glycerin	2400 J kg^{-1} K^{-1}
Methylated Spirits	2500 J kg^{-1} K^{-1}
Water	4200 J kg^{-1} K^{-1}

c Velocity of light in vacuo 2.997925 x 10^{-8} m s^{-1}

g Standard acceleration of gravity 9.80665 m s^{-2} or 9.80665 N kg^{-1}
(At Greenwich g = 9.81183 m s^{-2})

Speed of sound at sea level at 0°C = 331.7 m^{-1}

π= 3.142857

THE GREEK ALPHABET

Α	α	alpha	= a	Ν	ν	nu	= n
Β	β	beta	= b	Ξ	ξ	xi	= x
Γ	γ	gamma	= g	Ο	ο	omicron	= o
Δ	δ	delta	= d	Π	π	pi	= p
Ε	ε	epsilon	= e	Ρ	ρ	rho	= r
Ζ	ζ	zeta	= z	Σ	σς	sigma	= s
Η	η	eta	= ē	Τ	τ	tau	= t
Θ	θ	theta	= th	Υ	υ	upsilon	= u
Ι	ι	iota	= i	Φ	φ	phi	= ph
Κ	κ	kappa	= k	Χ	χ	chi	kh
Λ	λ	lambda	= l	Ψ	ψ	psi	ps
Μ	μ	mu	= m	Ω	ω	omega	ō

The Greek alphabet, apart from its use as the official script in Greek-speaking areas of the world, is of great importance as a source of symbols used in all branches of science and mathematics.

The guide to translating given above is an indication of the anglicised pronunciation of ancient Greek and not modern Greek.

The obsolete letters, digamma, episemon, koppa and san are not given above.

COMMON ELEMENTS and COMPOUNDS

Atomic, Ionic and Equivalent Weights

Common Name	Chemical Symbol	Common oxidation number or ionic charge	Atomic molecular or ionic mass	Equivalent Weight (*)
Aluminium	Al	3	27.0	9.0
Boron	B	3	10.8	3.5
Calcium	Ca	2	40.1	20.0
Calcium oxide	CaO		56.1	28.0
Carbon	C	4	12.0	3.0
bicarbonate	HCO_3	-1	61.0	61.0
carbonate	CO_3	-2	60.0	30.0
Chloride	Cl	-1	35.5	35.5
Chromium	Cr	6 (or 3)	52.0	8.7
dichromate	Cr_20_7	2	216.0	36.0
Gypsum	$CaSO_4.2H_2O$		172.2	86.1
$Hydro_9en$	H	1	1.0	1.0
Iron(III)(ferric)	Fe	3	55.8	18.6
Iron(II)(ferrous)	Fe	2	55.8	27.9
Magnesium	Mg	2	24.3	12.2
oxide	MgO		40.3	20.1
Manganese (IV)(manganic)	Mn	4	54.9	13.7
Manganese (II)(manganous)	Mn	2	54.9	27.5
Nitrogen	N	3	14.0	4.7
nitrate	NO_3	-1	62.0	62.0
Oxygen	O	2	16.0	8.0
Phosphorus	P	3 (or 5)	31.0	10.3
dihydrogen phosphate	H_2PO_4	-1	97.0	97.0
hydrogen phosphate	HPO_4	-2	96.0	48.0
phosphate	PO_4	-3	95.0	31.7
Potassium	K	1	39.1	39.1
oxide	K_2O		94.2	47.1
Silicon	Si	4	28.1	7.0
Sodium	Na	1	23.0	23.0
hydroxide	NaOH		40.0	40.0
Sulphur	S	2	32.1	16.0
hydrogen sulphate	HSO_4	-1	97.1	97.1
sulphate	SO_4	-2	96.1	48.0
sulphide	S	-2	32.1	16.0

* Equivalent wt of an element = atomic mass divided by valency

PERIODIC CHART OF ELEMENTS

IA												INERT GASES					
1 **H** 1.0079	IIA											IIIA	IVA	VA	VIA	VIIIA	2 **He** 4.0026
3 **Li** 6.9410	4 **Be** 9.0122											6 **B** 10.81	7 **C** 12.011	8 **N** 14.0067	9 **O** 15.9994	10 **F** 18.9984	11 **Ne** 20.179
11 **Na** 22.9898	12 **Mg** 24.3050	IIIB	IVB	VB	VIB	VIIB	-----	---VIII---	-----	IB	IIB	13 **Al** 26.9815	14 **Si** 28.0855	15 **p** 30.9738	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.08	21 **Sc** 44.9559	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.69	29 **Cu** 53.546	30 **Zn** 65.38	31 **Ga** 69.12	32 **Ge** 72.59	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.22	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.9055	46 **Pd** 106.42	47 **Ag** 107.868	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.9045	54 **Xe** 131.29
55 **Cs** 132.9054	56 **Ba** 137.33	57 ***La** 138.9055	72 **Hf** 178.49	73 **Ta** 180.9479	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.9665	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.20	83 **Bi** 208.9804	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.0254	89 **#Ac** 227.0278															

( ) Numbers in parentheses are mass numbers of most stable or most common isotope

Atomic weights are corrected to conform to the 1979 values iUPAC

* LANTHANUM SERIES													
58 **Ce** 140.12	59 **Pr** 140.9077	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.9254	66 **Dy** 162.50	67 **Ho** 164.9304	68 **Er** 167.26	69 **Tm** 168.9342	70 **Yb** 173.04	71 **Lu** 174.967

# ACTINUM SERIES													
90 **Th** 232.0381	91 **Pa** 231.0359	92 **U** 238.0389	93 **Np** 237.0482	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

THE CHEMICAL ELEMENTS

Element		Atomic Number	Atomic Mass	Density	M.Pt °C	B.Pt °C
Actinium	Ac	89	227.00	10.1	1230	3100
Aluminium	Al	13	26.98	2.7	660	2400
Antimony	Sb	51	121.75	6.7	630	1440
Argon	Ar	18	39.95		-189	-186
Arsenic	As	33	74.92	5.7	815	
Astatine	At	85	210.00		250	350
Barium	Ba	56	137.34	3.6	704	1600
Beryllium	Be	4	9.01	1.8	1280	2500
Bismuth	Bi	83	208.98	9.8	271	1477
Boron	B	5	10.81	2.5	2300	3700
Bromine	Br	35	79.91		-7.2	58
Cadmium	Cd	48	112.40	8.7	321	768
Caesium	Cs	55	132.90	1.9	28.6	690
Calcium	Ca	20	40.08	1.5	651	1440
Carbon	C	6	12.01	2.3	3500	3900
Cerium	Ce	58	140.12	6.8	804	2900
Chlorine	Cl	17	35.45		-101	-34.1
Chromium	Cr	24	51.97	7.2	1900	2600
Cobalt	Co	27	58.98	8.9	1492	2900
Copper	Cu	29	63.54	8.9	1088	2580
Dysprosium	Dy	66	162.50	8.5	1500	2300
Erbium	Er	68	167.26	9.0	1525	2600
Europium	Eu	63	151.96	5.2	830	1450
Fluorine	F	9	19.00		-220	-188
Francium	Fr	87	223.00		30	650
Gadolinium	Gd	64	157.25	7.9	1320	2700
Gallium	Ga	31	69.72	5.9	29.8	2250
Germanium	Ge	32	72.59	5.4	959	2850
Gold	Au	79	196.97	19.3	1063	2660
Hafnium	Hf	72	178.49	13.3	2000	5300
Helium	He	2	4.03		-271	-269
Holmium	Ho	67	164.93	8.8	1500	2300
Hydrogen	H	1	1.01		-259	-253
Indium	In	49	114.82	7.3	157	2000
Iodine	I	53	126.90	4.9	113	183
Iridium	Ir	77	192.2	22.4	2443	4550
Iron	Fe	26	55.85	7.9	1539	2800
Krypton	Kr	36	83.80		-158	-153
Lanthanum	La	57	138.91	6.15	920	3400
Lead	Pb	82	207.19	11.34	327	1750
Lithium	Li	3	6.94	0.53	180	1330
Lutetium	Lu	71	174.97	9.8	1700	3300
Magnesium	Mg	12	24.31	1.74	650	1100
Manganese	Mn	25	54.94	7.44	1245	2100
Mercury	Hg	80	200.59	13.59	-39	357
Molybdenum	Mo	42	95.94	10.2	2620	4600
Neodymium	Nd	60	144.24	6.96	1024	3100

THE CHEMICAL ELEMENTS (cont'd)

Element		Atomic Number	Atomic Mass	Density	M.Pt °C	B.Pt °C
Neon	Ne	10	20.18		-249	-246
Nickel	Ni	28	58.71	9.9	1453	2800
Niobium	Nb	41	92.91	8.57	2420	5100
Nitrogen	N	7	14.01		-203	-196
Osmium	Os	76	190.2	22.48	3000	4600
Oxygen	O	8	16.00		-218	-183
Palladium	Pd	46	106.4	12.0	1552	3200
Phosphorus	P	15	30.97		44	279
Platinum	Pt	78	195.09	21.45	1769	3800
Polonium	Pc	84	209	9.4	254	960
Potassium	K	19	39.10	0.86	63	760
Praseodymium	Pr	59	140.91	6.8	940	3000
Promethium	Pm	61	147		1000	2700
Protactinium	Pa	91	231	15.4	1200	4000
Radium	Ra	88	226	5.0	700	1140
Radon	Rn	86	222		-71	-62
Rhenium	Re	75	186.2	20.5	3180	5600
Rhodium	Rh	45	102.91	12.44	1960	3700
Rubidium	Rb	37	85.47	1.53	39	710
Ruthenium	Ru	44	101.07	12.4	2300	4100
Samarium	Sm	62	150.35	7.5	1050	1600
Scandium	Sc	21	44.96	3.0	1400	2500
Selenium	Se	34	78.96	4.81	220	688
Silicon	Si	14	28.09	2.3	1410	2500
Silver	Ag	47	107.87	10.5	961	2180
Sodium	Na	11	22.99	0.97	98	883
Strontium	Sr	38	87.62	2.6	77	1450
Sulphur	S	16	32.06	207	113	445
Tantalum	Ta	73	180.95	16.6	2996	5500
Technotium	Tc	43	99	11.4	2100	4600
Tellurium	Te	52	127.60	6.24	450	997
Terbium	Tb	65	158.92	8.3	327	2500
Thallium	TI	81	204.37	11.86	304	1460
Thorium	Th	90	232.04	11.5	1700	4200
Thulium	Tm	69	168.93	9.3	1600	2100
Tin	Sn	50	118.69	7.3	232	2600
Titanium	Ti	22	47.90	4.54	1680	3300
Tungsten	W	74	183.35	19.32	3380	5500
Uranium	U	92	288.03	19.05	1133	3800
Vanadium	V	23	50.94	6.1	1920	3400
Xenon	Xe	54	131.30		-112	-108
Ytterbium	Yb	70	173.04	7.0	824	1500
Yttrium	Y	39	88.91	4.6	1490	3000
Zinc	Zn	30	65.37	7.14	420	907
Zirconium	Zr	40	91.22	6.5	1857	4400

Atomic masses based on $^{12}_{6}C = 12$

Density given for solids at 20°C (293 K)
Melting and Boiling points rounded off to nearest degree

SELECTED INTERNATIONAL ATOMIC WEIGHTS AND PREPARATION OF STANDARD SOLUTIONS

Element		Atomic Mass	Standard Solution	
Aluminium	(Al)	26.98	1.759 $dm^{-3} Al_2(S0_4)_3$	100µg cm^{-3} Al
Antimony	(Sb)	121.76	0.100g Sb in 25cm^3 hot conc. H_2SO_4 and dilute to 100cm^3. Make up to 1dm^3 with 1:3 H_2S0_4	100µg cm^{-3} Sb
Arsenic	(As)	74.91	1.320g As_2O_3 in 500 cm^3 water 10cm^3 35% w/v NaOH. Neutralise with H_2SO_4 and dilute to 1dm^3	1000µg cm^{-3} As
Barium	(Ba)	137.36	0.1779g dm^{-3} $BaCl_2.2H_2O$	100µg cm^{-3} Ba
Beryllium	(Be)	9.01	By dilution of standard $BeCl_2$ solution.	
Bismuth	(Bi)	209.00	0.2321g $Bi(NO_3)_3.5H_2O$ in 5cm^3 1:10 HNO_3 and dilute to 1 dm^3	100µg cm^{-3} Bi
Boron	(B)	10.82	0.5716g dm^{-3} H_3B0_3	100µg cm^{-3} B
Bromine	(Br)	79.92	0.1489g dm^{-3} KBr	100µg cm^{-3} Br
Cadmium	(Cd)	112.41	0.1631g dm^{-3} $CdCl_2$(anhyd.)	100µg cm^{-3} Cd
Caesium	(Cs)	132.91	0.1267g dm^{-3} CsCl	100µg cm^{-3} Cs
Calcium	(Ca)	40.08	0.2497 dry $CaCO_3$ in 5cm^3 HCl; boil out CO_2 and dilute to 1dm^3	100µg cm^{-3} Ca
Carbon	(C)	12.01	———	———
Cerium	(Ce)	140.13	0.1228g CeO_2 in 10cm^3 1:2 H_2SO_4 with heat. Dilute to 1 dm^3	100µg cm^{-3} Ce
Chlorine	(Cl)	35.46	0.1648g dm^{-3} NaCl	100µg cm^{-3} Cl
Chromium	(Cr)	52.01	0.283g dm^{-3} dry $K_2Cr_2O_7$	100µg cm^{-3} Cr
Cobalt	(Co)	58.94	0.2630g dry $CoSO_4$ in 50cm^3 water plus 1 cm^3 conc. H_2S0_4. Dilute to 1 dm^3	100µg cm^{-3} Co
Copper	(Cu)	63.54	0.1964g dm^{-3} $CuSO_4.5H_20$	100µg cm^{-3} Cu
Fluorine	(F)	19.00	0.211g dm^{-3} NaF	100µg cm^{-3} F
Germanium	(Ge)	72.60	O.1441g GeO_2 in water.Add a few drops 12% NaOH,dilute, neutralize with 1:1 HCl, add drops HCl in excess and dilute to 100 cm^3	100µg cm^{-3} Ge
Gold	(Au)	197.00	0.1008g Na chloroaurate in 25 cm^3 1.OM HCl; dilute to 500cm^3	100µg cm^{-3} Au
Hydrogen	(H)	1.01	———	———
Iodine	(I)	126.91	0.1308g dm^{-3} Kl	100µg cm^{-3} I
Iron	(Fe)	55.85	0.7022g dm^{-3} ammonium iron(lll) sulphate plus 5cm^3 H_2SO_4	100µg cm^{-3} Fe
Lead	(Pb)	207.21	0.1599g $Pb(NO_3)_2$ in 1% HNO_3 and dilute to 1dm^3	100µg cm^{-3} Pb
Lithium	(Li)	6.94	0.6109g dm^{-3} LiCl	100µg cm^{-3} Li
Magnesium	(Mg)	24.32	1.0131g dm^{-3} $MgSO_4.7H_2O$	100µg cm^{-3} Mg
Manganese	(Mn)	54.94	O.3076g dm^{-3} dry $MnSO_4$	100µg cm^{-3} Mn
Mercury	(Hg)	200.61	O.1354g dm^{-3} $HgCl_2$	100µg cm^{-3} Hg
Molybdenum	(Mo)	95.95	0.150g MoO_2 in 10cm^3 1.0M NaOH, acidify with HCl and dilute to 1dm^3	100µg cm^{-3} Mo
Nickel	(Ni)	58.71	0.4479g dm^{-3} $NiSO_4.6H_2O$	100µg cm^{-3} Ni
Nitrogen	(N)	14.01	O.236g dm^{-3} $(NH_4)_2SO_4$ 0.361g dm^{-3} KNO_3 0.246g dm^{-3} $NaNO_2$	50µg cm^{-3} NH_4-N 50µg cm^{-3} NO_2-N 50µg cm^{-3} NO_2-N
Oxygen	(0)	16.00	———	———
Phosphorus	(P)	30.98	O.2195g dry KH_2PO_4 in 700cm water plus 25 cm^3 3.5M H_2S0_4 dilute to 1 dm^3	50µg cm^{-3} P

SELECTED INTERNATIONAL ATOMIC WEIGHTS AND PREPARATION OF STANDARD SOLUTIONS (cont'd)

ELEMENT		Atomic Mass	Standard Solution	
Platinum	(Pt)	195.09	0.1000g cleaned Pt in 1:3 HNO_3HCl. Evaporate nearly dry, and add 10cm^3 HCl and 0.06g NaCl. Re-evaporate and dilute to 1dm^3	100µg cm^{-3} Pt
Potassium	(K)	39.10	0.1907g dm^{-3} KCl	100µg cm^{-3} K
Rubidium	(Rb)	85.48	0.1415g dm^{-3} RbCl	100µg cm^{-3} Rb
Selenium	(Se)	78.96	0.1404g dm^{-3} SeQ_2	100µg cm^{-3} Se
Silicon	(Si)	28.09	By dilution of analyzed sodium silicate solution	
Silver	(Ag)	107.88	0.1575g dm^{-3} $AgNO_3$	100µg cm^{-3} Ag
Sodium	(Na)	22.99	0.2541g dm^{-3} NaCl	1000µg cm^{-3} Na
Strontium	(Sr)	87.63	0.2415g dm^{-3} $Sr(NO_3)_2$ anhyd	100µg cm^{-3} Sr
Sulphur	(S)	32.07	0.5370g dm^{-3} $CaSO_4.2H_2O$	100µg cm^{-3} S
Tellurium	(To)	127.61	0.1250g dm^{-3} TeO_2	100µg cm^{-3} Te
Thallium	(Tl)	204.39	0.1304g dm^{-3} $TlNO_3$	100µg cm^{-3} Tl
Thorium	(Th)	232.05	0.2379g dm^{-3} $Th(NO_3)_4.4H_2O$	100µg cm^{-3} Th
Tin	(Sn)	118.70	1.000g Sn in 100cm^3 1:1 HCl and dilute to 1dm^3 with 1:1 HCl	1000µg cm^{-3} Sn
Titanium	(Ti)	47.90	0.1668g TiO_2 fused with K pyrosulphate. Dissolve in 6M HCl and dilute to 1dm^3	100µg cm^{-3} Ti
Tungsten	(W)	183.86	0.18g dm^{-3} $Na_2WO_4.2H_2O$	100µg cm^{-3} W
Uranium	(U)	238.07	By dilution of analyzed uranyl nitrate solution	
Vanadium	(V)	50.95	0.2295g NH_4VO_3 in 100 cm^3 water plus 15cm^3 1:1 HNO_3. Dilute to 1dm^3	100µg cm^{-3} V
Zinc	(Zn)	65.38	0.100g Zn in 50cm^3 water plus 1 cm^3 conc. H_2SO_4 and dilute to 1dm^3	100µg cm^{-3} Zn
Zirconium	(Zr)	91.22	By dilution of standardized zirconium nitrate solution	

SOLVENT DATA SHEET

Substance	Fomula	Mr	B.P. °C	F.P. °C	S.G.	R.I.
Acetone	$(CH_3)_2CO$	58	56	-17	0.792	1.360
Amyl acetate	$CH_3COOC_5H_{11}$	130	125	25	0.87	1.401
Amyl alcohol	$C_5H_{11}OH$	88	126	44	0.816	1.408
Anisole	$CH_3OC_6H_5$	108	152	41	0.994	
Benzene	C_6H_6	78	80	11	0.880	1.501
Benzyl alcohol	$C_6H_5CH_2OH$	108	200	140	1.05	1.540
Butan-1-ol	C_4H_9OH	74	110	36	0.81	1.396
Carbon disulphide	CS_2	76	46	-20	1.268	1.635
Cyclohexanol	$C_6H_{11}OH$	100	160	49	0.945	1.468
Chloroform	$CHCl_3$	119.5	61	--	1.48	1.449
Carbon Tetrachlorlde	CCl_4	156	77	--	1.609	1.461
Diethanolamine	$(HOC_2H_4)_2NH$	105		138	1.10	
Diethyl ether	$(C_2H_5)_2O$	74	35	-28	0.720	1.350
Dioxan	$(CH_2CH_2O)_2$	88	100	12	1.031	1.42
Ethanol	C_2H_5OH	46	78	12	0.794	1.362
Ethyl acetate	$CH_3COOC_2H_5$	88	76	-0.5	0.906	1.373
Ethylene oxide	CH_2CH_2O	44		-17	0.9	
Ethylene glycol	$(CH_2OH)_2$	62	194	115	1.114	
Methyl Ethyl ketone	$CH_3COC_2H_5$	72	70	-7	0.805	1.379
Glycerol	$C_3H_5(OH)_3$	92		180	1.255	1.471
Methanol	CH_3OH	32	65	12	0.796	1.329
Nitropropane	$C_3H_7NO_2$	89	132	49	1.003	1.401
Nitrobenzene	$C_6H_5NO_2$	12.3	208	90	1.203	
Petrol ether			40-60	4	0.67	1.36
Propan-1-ol	C_3H_7OH	60	95	20	0.804	1.386
Pyridine	C_5H_5N	79	113	20	0.981	
Tetrachlorethane	$C_2H_2Cl_4$	168	147	--	1.601	1.495
Toluene	$C_6H_5CH_3$	92	109	7	0.868	1.496
Trichlorethylene	C_2HCl_3	131.5	87	--	1.471	1.479
Turpentine	$C_{10}H_{16}$	136		32	0.86	1.465
o-Xylene	$C_6H_4(CH_3)_2$	106	135	24	0.86	1.5

NORMAL and MOLAR SOLUTIONS DATA SHEET

A normal solution of a solute contains 1g-equivalent of solute per litre of solution. A molar solution contains lg-molecule of solute per litre of solution.

Substance	Density of usual concentrated solution	% purity	Volume required to make 1 litre of molar solution
Acetic Acid	1.05	99.5	$58cm^3$
Ammonia	0.880	35	$55cm^3$
Hydrochloric acid	1.18	36	$86cm^3$
Hydrofluoric acid	1.13	40	$44cm^3$
Nitric acid	1.42	70	$63cm^3$
Perchloric acid	1.54	60	$109cm^3$
Phosphoric acid (ortho)	1.75	90	$63cm^3$
Sulphuric acid	1.84	98	$54cm^3$
Hydrogen peroxide (20 vol)		6	$560cm^3$

SOLIDS

The details relate to Analytical Reagent standard materials where possible, and primary standards are marked P. (Z signifies sparingly soluble)

Substance	Formula	Mass in g req'd to make 1 litre of Molar solution	
Ammonium Ceric Nitrate	$(NH_4)_2[Ce(N0_3)_6]$		Z
Ammonium Ferrous Sulphate	$(NH_4)_2SO_4FeSO_46H_2O$		
Ammonium Persulphate	$(NH_4)_2S_2O_8$		Z
Ammonium Thiocyanate	NH_4CNS		
Arsenious Oxide	As_2O_3	197.82	PZ
Barium Hydroxide	$Ba(OH)_2.8H_2O$	315.50	Z
Borax	$Na_2B_4O_7.10H_2O$	381.42	P
Chromium Trioxide	$Cr0_3$	100.01	
Citric Acid	$H_3C_6H_5O_7.H_2O$	210.15	
Copper Sulphate	$CuSO_45H_2O$		
Iodine	I_2		P
Oxalic Acid	$(COOH)_2.2H_2O$	126.07	
Potassium Bromate	$KBrO_3$	167.02	P
Potassium Chloride	KCl		P
Potassium Dichromate	$K_2Cr_2O_7$	294.22	P
Potassium Hydrogenphthalate	$COOH.C_6H_4COOK$		P
Potassium Hydroxide	KOH		
Potassium lodate	KIO_3	214.01	P
Potassium Permanganate	$KMnO_4$	158.04	
Potassium Tetroxalate	$KH_3(C_2O_4)_22H_2O$	(as acid) (as reducer)	
Sequestric Acid, disodium salt. EDTA	$H_2Na_2C_{10}H_{12}O_82H_2O$	372.25	Z
Silver Nitrate	$AgNO_3$		
Sodium Carbonate (anhydrous)	Na_2CO_3	105.99	P
Sodium Chloride	$NaCl$		P
Sodium Bicarbonate	$NaHCO_3$		
Sodium Hydroxide	$NaOH$		
Sodium Oxalate	$(COONa)_2$	133.99	P

BUFFER SOLUTIONS

The tables below cover only the commonly used buffers and are not intended to be exhaustive. The first three tables are biologically compatible in that they do not contain materials which could interfere with enzymes or alter the structure of complex molecules other than changes due to changes in pH.

Table I

Citrate/Phosphate buffer (Proportions to give 100cm^3)

Desired pH	0.2M Na_2HPO_4 cm^3	0.1M Citric Acid cm^3
2.2	2.0	98.0
2.4	6.2	93.8
2.6	10.9	89.1
2.8	15.9	84.1
3.0	20.5	79.5
3.2	24.7	76.3
3.4	28.5	71.5
3.6	31.2	68.8
3.8	33.8	66.1
4.0	37.0	63.0
4.2	40.0	60.0
4.4	42.1	57.9
4.6	44.1	55.9
4.8	47.5	52.5
5.0	49.3	50.7
5.2	52.6	47.4
5.4	54.7	45.3
5.6	56.8	43.2
5.8	59.2	40.8
6.0	62.1	37.9
6.2	64.1	35.9
6.4	66.1	33.9
6.6	72.5	27.5
6.8	77.0	23.0
7.0	82.3	17.7
7.2	85.6	14.4
7.4	88.9	11.1
7.6	92.2	7.8
7.8	94.8	5.2
8.0	95.8	4.2

Table II

Phosphate buffer - 50cm^3 O.2M KH_2PO_4 plus stated volume O.2M NaOH diluted to 200cm^3

Desired pH	Volume of 0.2M NaOH
6.0	5.7
6.2	8.6
6.4	12.6
6.6	17.8
6.8	23.65
7.0	29.65
7.2	35.0
7.4	39.5
7.6	42.8
7.8	45.2
8.0	46.8

Table III

Acetate buffer - 20cm^3 of 1M sodium acetate plus the stated volume of IM acetic acid and diluted to 200cm^3

Desired pH	Volume of 1M acetic acid
4.1	70.0
4.2	60.0
4.4	49.0
4.6	25.0
4.8	20.0
5.0	12.5

BUFFER SOLUTIONS (cont'd)

Table IV	
Phthalate buffer 50cm^3 0.2M potassium hydrogen phthalate, plus stated volume of 0.2M HCl and diluted to 200cm^3 with water.	
Desired pH	Volume of 0.2M HCl
2.2	46.6
2.4	39.6
2.6	33.0
2.8	26.5
3.0	20.4
3.2	14.8
3.4	9.95
3.6	6.0
3.8	2.65
4 0	nil

Table V	
Borate buffer 0.7456g KCl + 0.618g H_3B0_3 in 50cm^3 water, plus stated volume of 0.2M NaOH and diluted to 200cm^3 with water.	
Desired pH	Volume of 0.2M NaOH
8.0	3.97
8.2	5.9
8.4	8.5
8.6	12.0
8.8	16.3
9.0	21.3
9.2	26.7
9.4	32.0
9.6	36.85
9.8	40.8
10.0	43.9

Table VI			
Buffers for EDTA titrations			
pH	Composition	Use	Indicator
10.0	67.5g NH_4Cl + 570cm^3 Ammonia (0.880) diluted to 1 litre	Ca; Mg; water hardness	Eriochrome _
	100cm^3 1M NH_4Cl + 500cm^3 1M NH	Most divalent heavy metals	Pyrocatechol violet
5.0	100cm^3 0.1M Ethanoic acid + 200cm^3 0.1 M Sodium acetate	Pb; Zn	Xylenol orange
2.0	500cm^3 1M Sodium ethanoate + 52.5cm^3 1M HCl diluted to 250cm^3	Bi	Xylenol orange

pH INDICATORS

The list oven below is not exhaustive but gives details of the most commonly used indicators. The list is divided into two sections, with the usual titrimetric indicators in the first section, but both lists are arranged In order of pH ranges covered.

Name	pH Range	Colour change	Usual solution
Methyl Orange	2.8 - 4.0	Red –Yellow	0.05% in water
Congo Red	3.0 - 5.0	Blue – Red	0.1% in water
Methyl Red	4.2 - 6.3	Red – Yellow	0.1% in 60% ethanol
Phenolphthalein	8.3 - 10.0	Colourless – Red	0.5% in 50% ethanol
Thymolphthalein	9.3 - 10.5	Colourless – Blue	0.04% in 60% ethanol
Cresol Red	0.2 - 1.8	Red – Yellow	1g+26.2cm^3 0.1M NaOH acid and dilute to 1 litre with water
	7.2 – 8.8	Yellow – Red	
Thymol Blue	1.2 - 2.8	Red – Yellow	1g+21.5cm^3 0.1M NaOH etc
	8.0 - 9.6	Yellow – Violet	
Bromophenol Blue	2.8 - 4.6	Yellow – Blue	1g+15.0cm^3 0.1M NaOH etc
Bromocresol Green	3.6 - 5.2	Yellow – Blue	1g+14.4cm^3 0.1M NaOH etc
Bromocresol Purple	5.2 - 6.8	Yellow – Violet	1g+18.6cm^3 0.1M NaOH etc
Bromothymol Blue	6.0 - 7.6	Yellow – Blue	1g+16.0cm^3 0.1M NaOH etc
Phenol Red	6.8 - 8.4	Yellow – Red	1g+28.4cm^3 0.1M NaOH etc

OTHER TITRIMETRIC INDICATORS

Name	Usual Solution	Quantity Used
Barium diphenylamine sulphonate	0.3% aqueous	5 drops
N-phenylanthranilic acid	0.107g + 0.lg Na_2CO_3 made up to 100cm^3 water	0.5cm^3
Feroin	1.487g o-phenanthroline in Water, add 0.656g iron (II) sulphate heptahydrate and make up to 100cm^3	1 drop
Potassium chromate	5% aqueous	1 cm^3
Dichlorofluorescein	0.1% in 65% ethanol	5 drops
Iron (III) alum	14g iron(III) alum in water, add HNO_3 until yellow and dilute to 100cm^3	1cm^3
Eriochrorne Black T	0.5g + 100g NaCl powdered	about 0.2g
Murexide	1g + 100g NaCl powdered	about 0.2g
Pyrocatecol violet	0.1% aqueous	2-3 drops
Xylenol orange	0.1% in 50% ethanol	2-3 drops
Starch	1g shaken in water and poured into 100cm^3 of boiling water	1cm^3

COMPRESSED GASES in CYLINDERS

Identification of Contents

The traditional colours associated with identifying particular gases in the 1932 edition of the BS standard were retained in the 1973 edition together with the principle of using yellow or red colour bands to denote toxic or flammable gas, respectively, but emphasis was placed on marking the container with the name of the gas and the chemical formula or symbol. The so-called ground colour of the container thus had less significance than before.

CEN, the European Committee for Standardization will in due course produce a standard for identification of compressed gases in cylinders that will replace the existing standards of member states. Until then the present BS 349: 1973 standard given below will remain the recommended identification of industrial compressed gases in the U.K.

Marking		Ground colour of container	Colour of bands
Acetylene	C_2H_2	Maroon	None
Air		French Grey	None
Ammonia	NH_3	Black	Signal red and golden yellow
Argon	Ar	Peacock Blue	None
Carbon dioxide	CO_2	Black	None
Carbon monoxide	CO	Signal red	Golden yellow
Chlorine	Cl_2	Golden yellow	None
Coal gas		Signal red	None
Ethyl chloride	C_2H_5Cl	French grey	Signal red
Ethylene	C_2H_4	Dark violet	Signal red
Ethylene oxide	C_2H_4O	Dark violet	Signal red and golden yellow
Helium	He	Middle brown	None
Hydrogen	H_2	Signal red	None
Hydrogen cyanide	HCN	Peacock Blue	Golden yellow
Methane	CH_4	Signal red	None
Methyl bromide	CH_3Br	Peacock blue	Black
Methyl chloride	CH_3Cl	Light Brunswick green	Signal red
Neon	Ne	Middle brown	Black
Nitrogen	N_2	French grey	Black
Oxygen	O_2	Black	None
Phosgene	$COCl_2$	Black	Peacock blue and golden yellow
Propane		Signal red	None
Sulphur dioxide	SO_2	Light Brunswick green	Golden yellow

COMPRESSED GASES in CYLINDERS (cont'd)

OTHER GASES

(any ground colour except those used in the table on the previous page)

Boron trifluoride	BF_3	Golden yellow
Butane		Signal red
Dichlorodifluromethane	CCl_2F_2	None
Difluorethane	$C_2H_4F_2$	Signal red
Difluoromonochloroethane	$C_2H_3ClF_2$	Signal red
Ethane	C_2H_6	Signal red
Ethyl bromide	C_2H_5Br	Golden yellow
Fluorine	F_2	Golden yellow
Hydrogen chloride	HCl	Golden yellow
Hydrogen fluoride	HF	Golden yellow
Hydrogen sulphide	H_2S	Golden yellow
Krypton	Kr	None
Monochlorodifluoromethane	$CHClF_2$	None
Nitrogen peroxide	N_2O_4	Golden yellow
Nitrosyl chloride	NOCl	Golden yellow
Propylene		Signal red
Sulphur hexafluoride	SF_6	None
Vinyl chloride	C_2H_3Cl	Signal red
Xenon	Xe	None

Medical gas containers are excluded from BS349:1973. The identification of these is covered in BS1319.

COMMON BIOLOGICAL SOLUTIONS

i) Isotonic Salines:

Frog, 0.65% NaCl (w/v)
Mammal, 0.9% NaCl (w/v)

ii) Perfusion Fluids:

All masses given in the table to be made up to 1000cm^3

Frog	Ringer	Locke	Tyrode
Sodium chloride	6.5g	9.0g	8.0g
Potassium chloride	0.14g	0.42g	0.2g
Calcium chloride (anhyd)	0.12g	0.24g	0.2g
Sodium hydrogen carbonate	0.2g	0.2g	1.0g
Sodium dihydrogen phosphate	0.01g	0.05g	0.05g
Magnesium chloride (anhyd)			0.1g

iii) Fixatives:

Bouin's Solution:	Saturated aqueous picric acid solution Formaldehyde solution (40%) Glacial acetic acid	75cm^3 25cm^3 5cm^3
Flemming's Solution:	1% aqueous chromium trioxide solution 2% aqueous osmic acid solution Glacial acetic acid (This solution does not keep well, make up as required)	15cm^3 4cm^3 1cm^3
Formol-saline:	0.9% aqueous sodium chloride solution formaldehyde solution (40%) (keep neutral by adding a few granules of calcium carbonate)	90cm^3 10cm^3
Schaudinn's Solution:	Saturated aqueous mercuric chloride Ethanol (absolute) Glacial acetic acid	66cm^3 33cm^3 1cm^3

iv) Common Stains:

The examples given are common general purpose stains. This list is not intended to be complete and the usual literature sources can provide further examples and more details

Carbol Fuchsln:	Fuchsin (basic)	1g
	Phenol crystals	5g
	Ethanol, 95%	10c m^3
	Water, (deionised or distilIed)	100cm^3
The fuchsin is dissolved in the phenol by heating on a water bath and mixing well. Add the ethanol, stir, add the water, and filter. This solution should be dilluted with water (1:10) for use in Gram staining.		
Crystal Violet	Crystal Violet	2g
- **Ammonium Oxalate:**	Ammonium oxalate	0.8g
	Ethanol, 95%	20cm
	Water	to 100cm^3
Dissolve the dye in the alcohol, add the oxalate dissolved in a little water. mix well, and dilute to 100cm^3 with water.		

Haematoxylin, Ehrlich's:	Haematoxylin	2g
	Ethanol, 95%	100cm^3
	Glycerol Glacial Acetic Acid	100cm^3
		10cm^3
	Ammonium alum Water	3g
		100cm^3
Dissolve the haematoxylin in the alcohol, add the glycerol and the acetic acid. Dissolve the ammonium alum in the water, and add this solution to the other and mix well. The mixture should be left to oxidise in an unstoppered plain glass bottle for some weeks, but the oxidation period can be reduced by adding 0.4g of sodium periodate.		
Iodine, Gram's:	lodine	1g
	Potassium Iodide	2g
	Water	300cm^3
Iodine, Lugol's:	As for Grams iodine but using only 100cm^3 of water.	
Leishman's stain:	Leishman stain	0.15g
	Methanol	100cm^3
Add the stain to the methanol and mix well. Allow to stand with occasional shaking, for at least 24 hours, and then filter.		
Methylene Blue, Loeffler's:	Methylene blue, saturated ethanolic solution	30cm^3
	Potassium hydroxide	0.01g
	Water	100cm^3
Eosin:	1% aqueous solution, or 1% in 20% ethanol	

v) Botanical Materials:

Plant Preserving Media	**(a)**	95% ethanol	60cm^3
		Water	40cm^3
		Formaldehyde (40%)	4cm^3
		Glacial Acetic Add	4cm^3
	(b)	95% ethanol	36cm^3
		Water	60cm^3
		Formaldehyde (40%)	4cm^3
		Cupnc sulphate crystals	0.2g
Stains			
Fast Green FCF:		Methyl Cellosolve	30cm^3
		Ethanol (absolute)	30cm^3
		Clove Oil	30cm^3
		FCF Powder	0.45g
Light Green SF:		Light Green powder	1.0g
		Clove Oil	100cm^3
The mixture should be heated on a boding water bath until apparently dissolved, allowed to cool, and then filtered.			
Safranin:		SafraninO	1.0g
		Ethanol, 70%	100cm^3
Preparation of root tips for nuclear staining	**(a)**	Clarks Fluid	
		Glacial Acetic acid	25cm^3
		Ethanol	75cm^3
	(b)	Orcein-acetic stain	
		Stock Solution	
		2.2g Orcein dissolved and made up to 100cm^3 with a 45% v/v solution of acetic acid in water.	
		Working solution(made just when required)	
		Stock solution	10cm^3
		Water	12cm^3

vi) Some Useful Solutions:

Knops solution for algae culture	$MgSO_4.7H_2O$	0.1g
	K_2HPO_4	0.2g
	KNO_3	1.0g
	$Ca(N0_3)_2$	0.1g
	Water to 1 litre	
Chalkey's solution for amoeba culture		
Stock Solution	NaCl	10g
	KCl	0.4g
	$CaCl_2$	0.6g
	Water to $500cm^3$	
Working Solution	Take 1ml of stock solution and dilute to $200cm^3$ with water. Add 2 wheat grains to every $25cm^3$ required, boil, cool, and adjust to 5.8-6.0 if necessary, by adding dilute HCl.	
Dilutents for blood counting		
Turks Solution for WBC (Leucocytes)	Add a trace of gentian violet to $100cm^3$ of 1% v/v acetic acid in water.	
Torissons solution for RBC (Erthrocytes)	To $160cm^3$ of water add 1g sodium chloride, 8g sodium sulphate, and $30cm^3$ glycerol.	
Bicarbonate Indicator		
Stock Solution	Prepare a solution of 0.02g Thymol blue and 0.01g Cresol red in $2cm^3$ ethanol, and a solution of 0.084g $NaHCO_3$ and 7.48g KCl in $90cm^3$ water, and mix the two solutions.	
Working Solution	Add 1ml of the stock solution to $10cm^3$ of water.	

SOME USEFUL INFORMATION

Chemistry Data

Effect of temperature variation on electrochemical data

(a) pH of standard buffers used in pH meter calibration

pH 4 buffer						
°C	0	10	20	25	30	40
pH	4.00	4.00	4.00	4.01	4.02	4.04
pH 9 buffer						
°C	0	10	20	25	30	40
pH	9.49	9.35	9.24	9.19	9.14	9.07

(b) Electrode potential of calomel reference electrodes

°C	18	20	25	30	35	40
E^{θ}(0.1M KCl)	0.336	0.335	0.335	0.335	0.334	0.333
E^{θ}(1M KCl)	0.280	0.280	0.278	0.277	0.277	0.277
E^{θ}(sat KCl)	0.249	0.248	0.244	0.240	0.236	0.232

(c) Vapour pressure of water

°C	kN m^{-2}
10	1.23
11	1.31
12	1.40
13	1.50
14	1.60
15	1.70
16	1.82
17	1.94
18	2.06
19	2.19
20	2.34
22	2.64
24	2.98
25	3.17
30	4.24
35	5.62
40	7.38
45	9.58
50	12.35
55	15.74
60	19.62
70	31.16
80	47.35
90	70.10
100	101.32

RESISTORS - COLOUR CODE

The colours on resistors are used to indicate the nominal value of their resistances, and the permitted tolerance on that value. In the colour band system, the resistor has three or four bands on it The band at the end of the resistor indicates the first digit, the next band (working towards the centre of the resistor) indicates the second digit white the third band indicates the number of zeros which follow the previous two digits. The fourth band is used to indicate the manufacturers tolerance.

Some resistors are marked by the body, tip and dot system in which the first digit is indicated by the colour of the body of the resistor, the second digit by the band at one end of the resistor, and the number of zeros, by the band, or dot, in the centre of the resistor.

The colours used are as follows:

0	Black	
1	Brown	
2	Red	
3	Orange	
4	Yellow	
5	Green	For the tolerance band
6	Blue	
7	Violet	20% no band
8	Grey	10% silver
9	White	5% gold

The use of colour codes for resistors is usually limited to carbon composition and similar resistors. Non-inductive wire wound resistors normally have their value written or printed on a plain coloured background.

Most manufacturers produce a range of preferred values. This limits the total number of different values required. The intermediate values are spanned by the tolerance of the resistors.

FUSES - COLOUR CODE

These are often marked by coloured dots on the glass of the fuse. The rating of the fuse is given by the following code:

60	mA	Black	500	mA	Yellow	2.0	A	Purple
100	mA	Grey	750	mA	Green	3.0	A	White
150	mA	Red	1.0	A	Dark Blue			
250	mA	Brown	1.5	A	Light Blue	5.0	A	Black & White

WORKSHOP DATA

Cutting Speeds For Machines

Material worked	Metres per minute	Feet per minute
Tool Steel	13-20	45-65
Mild Steel	25-35	90
Cast Iron	13-20	45-65
Brass	50-80	150-240
Copper	50-80	150-240
Aluminum Alloy	65-140	180-400
Bronze	13-23	40-70
Zinc Alloys	30-50	90.150
Stainless Steel	13-30	40-90
Plastic	35-60	100-180

Cutting Lubricants

Tool Steel	Soluble Oil
Mild Steel	Soluble Oil
Stainless Steel	Soluble Oil
Cast Iron	Dry
Brass	Dry. Soluble Oil or Paraffin
Copper	Dry, Soluble Oil or Paraffin
Aluminum Alloy	Dry, Soluble Oil or Paraffin
Bronze	Dry, Soluble Oil or Paraffin
Zinc Alloy	Dry. Soluble Oil or Paraffin
Plastics	Dry

Flame Temperatures

Combustible	Diluent	% Combustible	Flame Temperature (°C)
Methane	Air	10.0	1875
Propane	Air	4.15	1925
Butane	Air	3.2	1895
Iso-butane	Air	3.2	1900
Acetylene	Air	9.0	2325
	Oxygen	18.0	2927
		33.0	3007
		44.0	3137
		50.00	2927

Tempering Colours on Steel

Type of Tool	Colour	Temperature (°C
Scrapers; tools for use on brass	Pale Straw	220
Drills; small lathe tools	Straw	230
Drills; hammers; reamers	Dark Straw	240
Shears; scissors; dies and tapes; punches	Brown	255
Axes; woodworking tools	Brown/Purple	265
Knives; sets; cold chisels	Purple	280
Smiths tools; circular saws; screwdrivers	Blue	295
Springs; handsaws	Dark Blue	305
Rules	Pale Blue	340

WORKSHOP DATA (cont'd)

Solders and Fluxes

Material	Flux	Solder Alloy (% Composition)					
		Sn	Pb	Zn	Al	Bi	Sb
Aluminum	Stearin	85		10	5		
Brass of Copper	Zinc chloride	65	35				
Electrical work	Resin in solder core	60	39.5				0.5
Galvanised sheet or zinc	Dilute Hydrochloric acid	50	50				
Lead	Tallow	30	70				
Brittania metal or Pewter	Tallow or Gallipoli oil	25	25			50	
Tinplate	Zinc chloride	50	50				

Melting Points of Metals and Alloys (°C)

Cast Iron	1200 - 1400
Wrought Iron	1600 - 1700
Tool Steel	1200 - 1400
Mild Steel	1200 - 1350
Aluminum	700
Copper	1083
Brass (including gilding metal)	930 - 1010
Tin	231
Zinc	419
Lead	327
Silver	800 - 910

Grinding Wheel Speeds (Peripheral)

Metal Tool Grinder	850 – 1250 metres per minute
Woodwork Tool Grinder	125 – 200 metres per minute
Horizontal Grindstone	125 - 175 metres per minute
Sandstone	125 – 150 metres per minute

Heat Treatment of Carbon Steels

Normalising
Process used to refine the grain structure and relieve internal stress.
Heat above the upper critical temperature and allow cooling in air.

Annealing
Process used to soften steel for machining.
Heat above the upper critical temperature and allow cooling very slowly in the furnace.

Hardening
Makes the steel very hard and brittle
Heat above the upper critical temperature and quench in water or oil.

Case Hardening
A method of hardening the outer skin of the steel by increasing carbon content.
Heat to red heat and plunge in to charcoal dust. Repeat the process several times before bringing to hardening temperature and quenching in water.

Tempering
Hardened tool steels are inclined to be brittle.
Tempering is a process which reduces the brittleness without loosing too much of the hardness. The compromise between hardness and toughness varies for different tools.

TAPPING AND CLEARANCE DRILL SIZES

Système Internationale (SI)		
Size mm	**Tap Drill Size**	**Clearance Drill Size**
6	5mm	6.2mm
7	6mm	9/32in
8	17/64in	8.2mm
9	7.7mm	23/64in
10	8.4mm	10.25mm
11	9.5mm	11.25mm
12	10.25mm	31/64in
14	12mm	9/16in
16	35/64in	41/64in
18	39/64in	23/32in
20	11/16in	51/64in
22	49/64in	22.25mm
24	21mm	24.25mm
27	24mm	1 5/64in
30	26.5mm	1 3/16in
British Association Thread (BA)		
Designating Number	**Tap Drill Size**	**Clearance Drill Size**
0	5.1mm	6.1mm
1	4.5mm	5.4mm
2	4.0mm	4.8mm
3	3.4mm	4.2mm
4	3.0mm	3.7mm
5	2.65mm	3.3mm
6	2.3mm	2.9mm
7	2.05mm	2.6mm
8	1.8mm	2.25mm
9	1.55mm	1.95mm
10	1.4mm	1.75mm
11	1.2mm	1/16in
12	1.05mm	1.4mm
13	0.98mm	1.3mm
14	1/32in	1.1mm
15	0.7mm	0.98mm
16	0.6mm	0.88mm

WOOD SCREWS, CLEARANCE and THREAD HOLE SIZES

Gauge of Screw	Clearance Hole inch	Thread Hole inch
0000		
000	1/16	1/32
00		
0	5/64	3/64
1	5/64	3/64
2	3/32	1/16
3	7/64	1/16
4	1/8	5/64
5	1/8	5/64
6	5/32	5/64
7	5/32	3/32
8	3/16	3/32
9	3/16	1/8
10	7/32	1/8
11	7/32	1/8
12	1/4	1/8
13	1/4	5/32
14	1/4	5/32
15	9/32	5/32
16	9/32	3/16
17	5/16	3/16
18	5/16	3/16
20	11/32	7/32
22	3/8	7/32
24	7/16	1/4
26	7/16	1/4
28	1/2	9/32
30	1/2	9/32
32	9/16	5/16
36	5/8	11/32
40	11/16	3/8
50	13/16	7/16

SHEET METAL AND ENGLISH STANDARD WIRE GAUGE, SWG

SWG No.	Diameter/Thickness inch	Diameter mm
1	0.300	7.620
5	0.212	5.385
10	0.128	3.251
12	0.104	2.641
14	0.080	2.032
16	0.064	1.626
18	0.048	1.219
20	0.036	0.914
22	0.028	0.711
24	0.022	0.559
26	0.018	0.457
28	0.015	0.376
30	0.0124	0.315
32	0.0108	0.274
34	0.0092	0.234
36	0.0076	0.1930
38	0.0060	0.1524
40	0.0048	0.1219
42	0.0040	0.1016

SELECTION OF ADHESIVES

Use the following table of materials, and the adhesives that will bond to them, by looking up the two materials to be joined and selecting an adhesive Which will bond to both.

Material	Adhesives that Bond
Plastics:	
GRP	Epoxy Polyester Melamine formaldehyde Rubber cement (if low peel strength is acceptable)
Acrylic (Perspex)	Acrylic cement (Perspex in solvent) Epoxy Rubber cement
Cellulose acetate	Cellulose acetate in solvent Balsa cement Epoxy
Cellulose nitrate	Cellulose nitrate in solvent Balsa Cement Epoxy
Thermosetting plastic	Epoxy Rubber cements UF resin Polyester resin
Polystyrene	'Plastic cement' (polystyrene in solvent) Epoxy
Expanded polystyrene	PVA Expanded polystyrene adhesive
Nylon	Epoxy Phenolic rubber cement Resorcinol
PTFE ('Teflon')	Silicone Phenolic rubber cement
PVC	Phenolic rubber cement Nitrile rubber solution
Polythene	Silicone Phenolic rubber cement
Wood (including balsa and hardboard)	PVA UF resin PF resin Epoxy Resorcinol Balsa cement Rubber cements Polyurethane Polyester Latex Casein Dextrin, starch and gums can be used to attach paper, but not for structural joints.
Metals	Epoxy Cyanoacrylate Polyester Polyurethane Phenolic rubber cement PVA, it a weak bond is acceptable

Paper	Starch Dextrins Gums PVA Balsa cement Cow gum Cellulose adhesive (polycel) Latex Rubber solutions
Glass	Polyester Epoxy Rubber cements
Concrete	Latex-bitumen

Note. Oily woods such as teak may have to be scrubbed with weak caustic soda solution and glued with UF resin (epoxy or polyester resins can be used if the wood is first thoroughly dried).

CHEMICAL RESISTANCE OF VARIOUS GLOVE TYPES

Chemical	Natural Rubber			Nitrile	PVC	Neoprene
	L	M	H			
Nitric acid 50%	X	X	S	S	G	G
Sulphuric acid 50%	S	E	E	E	E	E
Ethanoic acid 100%	X	F	G	F	F	G
Ammonia "880"	F	G	E	G	E	E
Sodium hydroxide, sat.	F	G	E	F	E	E
Copper(II) sulphate,sat.	F	G	E	G	E	E
Ethoxyethane	X	F	G	G	F	G
Propanone	F	G	E	X	X	E
Methanol	F	E	E	G	G	E
Ethanol	G	E	E	G	F	E
Phenylamine	X	X	S	X	G	S
Petroleum spirit	X	F	G	E	F	G
Methylbenzene	X	X	X	S	F	S
1,1,1-Trichlorethane	X	X	X	S	X	X
Hydrogen peroxide, 100 vols.	G	G	E	G	E	E
Detergent solutions	G	G	G	F	G	E

CODE: L=LIGHT WEIGHT M=MEDIUM WEIGH H=HEAVYWEIGHT
X=NIL F=FAIR G=GOOD
E=EXCELLENT S=SPLASH ONLY

UNIVERSAL ANTIDOTE FOR POISONS

Activated powdered charcoal	2 parts by weight
Magnesium oxide	1 part by weight
Tannic acid	1 part by weight

The mixture should be stored dry and when required for use, add 15g to half a glass of warm water

Cyanide Antidotes

For inhaled cyanides the patient should be allowed to inhale amyl nitrate for 15-30 seconds every 2-3 minutes for a maximum of 15 minutes

For ingested cyanides, if the patient is conscious allow him to drink the following:

Solution A	158g of ferrous sulphate plus 3g of citric acid made up to 1 litre in cold distilled water
Solution B	60g of anhydrous sodium carbonate made up to 1 litre in cold distilled water

The solutions are stored separately and equal volumes are mixed when required for use

For intravenous injection by medical aid, ampoules of 20ml, each containing 300mg of Cobalt EDTA (trade name Kelocyanor) should be available

PHYSICS DATA

Electrical Resistivities at 20°C and Temperature Coefficients of Resistance per °C

	Resistivity ohm metre	Temperature Coefficient
Elements		
Aluminum	3.21×10^{-8}	38.0×10^{-4}
Antimony	40.5×10^{-8}	
Bismuth	119.0×10^{-8}	42.0×10^{-4}
Cobalt	9.7×10^{-8}	33.0×10^{-4}
Copper, Drawn	1.78×10^{-8}	42.8×10^{-4}
Annealed	1.59×10^{-8}	42.8×10^{-4}
Gold	2.42×10^{-8}	40.0×10^{-4}
Iron, Pure	11.5×10^{-8}	62.0×10^{-4}
Steel 0.1C	20.0×10^{-8}	29.0×10^{-4}
Lead	20.8×10^{-8}	43.0×10^{-4}
Mercury	95.76×10^{-8}	9.0×10^{-4}
Nickel 97%	11.8×10^{-8}	27.0×10^{-4}
Silver	1.65×10^{-8}	40.0×10^{-4}
Tin	11.3×10^{-8}	45.0×10^{-4}
Zinc	6.1×10^{-8}	37.0×10^{-4}
Alloys		
Brass	8.0×10^{-8}	10.0×10^{-4}
German Silver	28.0×10^{-8}	4.4×10^{-4}
Manganin	43.0×10^{-8}	0.1×10^{-4}
Nichrome	110.0×10^{-8}	1.7×10^{-4}
Phosphor Bronze	8.0×10^{-8}	
Miscellaneous		
Graphite	3.0×10^{-6}	
Ebonite	2.0×10^{17}	
Glass, Pyrex	10^{16}	
Soda	5.0×10^{13}	
Mica	9.0×10^{17}	
Paraffin Wax	3.0×10^{20}	
Quartz	1.4×10^{16}	

German Silver	60 Cu,	15 Ni,	25 Zn
Manganin	84 Cu,	4 Ni,	12 Mn

WAVE-LENGTHS OF IMPORTANT SPECIAL LINES IN AIR AT 15°C and 760 mm Hg PRESSURE

Line		Wave-length (n m)
K red		766.8
O red	(A)	759.4
O red	(B)	687.0
Li red		670.8
Hα red		656.3
Cd red*		643.84696
Li orange		610.4
Na orange	(D_1)	589.59
Na orange	(D_2)	589.00
Na orange	(D_3)	587.56
He yellow		586.0
Ti green		535.1
Fe and Ca Green	(E)	527.0
Mg green	(b_1)	517.8
Mg green	(b_2)	517.3
Mg green	(b_4)	516.7
Cd green*		508.582
Hβ blue-green	(F)	486.1
Cd blue*		479.991
Sr blue		460.8
Li blue		460.2
Hţ blue	(G_1)	434.0
Fe and Ca blue	(G)	430.8
Ca blue	(g)	422.7
K violet		404.7
Radium		670.0
Zinc		610.3
Argon		603.1
Boron		600.0
Neon		585.3
Copper		570.0
Barium		553.6
Mercury		546.1
Iron		527.0
Caesium		455.5
Indium		451.1
Rubidium		421.6
Aluminum		396.2

An everyday standard is taken as Sodium =589.3nm

* Accepted standard lines

MOH'S SCALE OF HARDNESS

Substance	Hardness
Talc	1
Gypsum (Rock-salt)	2
Calcite	3
Fluorite	4
Apatite	5
Orthodase (Felspar)	6
Quartz	7
Topaz	8
Corundum (Emery)	9
Diamond	10

Tabor (1954) has shown the relation log H = nM to hold for the first nine substances, where H is the indentation hardness in kg/mm^2, M is Moh's number and n is about 1.6

The order of the minerals in this table may be remembered by the following odd sentence: 'The Girls Can Flirt And Other Quaint Things Can Do.'

Some other convenient standards of hardness are:

Finger Nail	2.5
Bronze Coin	4
Window Glass	5.5
Knife Blade	6
Steel File	6.5

USEFUL PHOTOGRAPHY DATA

D76/ID11(General purpose, fine grain developer)

Metol cryst	2g
Sod. sulphite anhyd.	100g
Quinone (hydroquinone) cryst	5g
Borax cryst	5g

Make up to 1 litre with water.

Working solution: Dilute with water 1+1. Typical dev. time at 20°C: 7-12 mm.

D72 (Print developer)

Metol cryst	3g
Sod. sulphite anhyd	45g
Quinone cryst	12g
Sod, carbonate anhyd	67.5g
Pot bromide cryst	2g

Make up to 1 litre with water.

Working solution: Dilute with water 1 +2 Typical dev. time at 20°C: 1 to 2 mins.

BEERS (Variable contrast print developer)

Stock soln. A		Stock soln. B	
Water at 50°C	750cm^3	Water at 50°C	750cm^3
Metol	8g	Quinone	8g
Sod. sulphite anhyd.	23g	Sod. sulphite anhyd.	23g
Pot carbonate anhyd	20g	Pot carbonate anhyd	27g
Pot bromide cryst	1.1g	Pot bromide cryst	2.2g
Make up to 1 litre with water		Make up to 1 litre with water	

Contrast	Parts A	Parts B	Parts Water
Low	8	0	8
Normal	5	3	8
High	2	14	0

AN-79B (Lith developer)

Stock soln, A		Stock soln. B	
Sod. sulphite anhyd	1g	Sod. suiphite anhyd	120g
Paraformaldehyde	30g	Boric acid cryst	30g
Pot. metabisulphite	10.5g	Quinone	90g
		Pot. bromide	6g
Make up to 1 litre with water		Make up to 3 litre with water	

Working soln.: 1 part A + 3 parts B (Make up just before use)
Typical dev. time at 20°C: 2 mins.

USEFUL PHOTOGRAPHY DATA (cont'd)

FIXERS

	Hardening acid Fix	Rapid Hardening Acid Fix (*)
Water at 50°C	600cm^3	600cm^3
Sod. thiosulphate cryst	240g	360g
Ammonium chloride		50g
Sod. sulphite anhyd	15g	15g
Acetic acid (80% sol.)	17cm^3	17cm^3
Boric acid ayst	7.5g	7.5g
Pot alum		15g
Make up to 1 litre with water		Make up to 1 litre with water

(*) Prolonged fixing time may bleach image.

Hypo-Alum Sepia Toner

Cold water	700cm^3
Sod. thiosulphate anhyd.	120g

Dissolve thoroughly, then add the following soln.

Water at 70°C	200cm^3
Pot. alum cryst	30g

Slowly add he following soln. including its milky precipitate, while stirring vigorously.

Cold water	20cm^3
Silver nitrate cryst	1g
Sod. chloride	1g

Make up to 1 litre with water.

Prints treated in the final toner turn chocolate brown 1 about 12-15 mins.

Farmer's Reducer

Soln. A		Soln. B	
Water	250cm^3	Warm water	1000cm^3
Pot. ferricyanide	37.5g	Sod. thiosulphate cryst	480g
Make up to 500cm^3 with water		Make up to 2 litres with water.	

Mix one part A with 8 parts B and 50 parts water just before use.

For faster reduction of density, double the quantity of soln. A.

COMPARATIVE FILM SPEEDS

Grain	ISO	ASA	DIN	Speed
Fine	25/15°	25	15°	Slow
	32116°	32	16°	
	50/18°	50	18°	
	64/19°	64	19°	
Medium	80/20°	80	20°	Medium
	100/21°	100	21°	
	125/22°	125	22°	
	160/23°	160	23°	
	200/24°	200	24°	
Coarse	400/27°	400	27°	Fast
	800/30°	800	30°	
	1000/31°	1000	31°	
	2000/34°	2000	34°	
	3200/36°	3200	36°	

At the present time most manufacturers quote an ISO (International Standards Organisation) rating for film speeds. This combines the previous American Standards Association (ASA) rating and European Deutsche Industrie Normen (DIN) rating. In the ASA system doubling the number indicates that the film speed has been doubled. In the DIN system an increase of 3° indicates that the film speed has been doubled.

DENSITOMETRY DATA

This table showing the relation between Density, Opacity and Transmission (%) enables one to convert densitometer readings into opacity and transmission values. Thus, first measuring the maximum and minimum densities on a densitometer and then converting them to opacity values may estimate the Opacity Scale of a negative, which is the ratio of the maximum - to the minimum - opacity values.

Density	Opacity	Transmission	Density	Opacity	Transmission
0	1.0	100	1.6	40.0	2.5
0.2	1.6	63	1.8	63.0	1.6
0.4	2.5	40	2.0	100.0	1.0
0.6	4.0	25	2.2	160.0	0.63
0.8	6.3	16	2.4	250.0	0.4
1.0	10.0	10	2.6	400.0	0.25
12	16.0	6.3	2.8	630.0	0.16
1.4	25.0	4.0	3.0	1000.0	0.10

MACROPHOTOGRAPHY DATA

Increase in exposure required when using extension tubes or bellows:

$\frac{(L + E)^2}{L^2}$ = Exposure factor where E is the additional extension

Example: focal length = 5cm; extension = 5cm

$$\frac{(5+5)^2}{5^2} = \frac{(10)^2}{5^2} = \frac{100}{25} = x4$$

increase exposure four times (i.e. open up two stops)