C_5H_{12}, *n*-Pentane(41)

t, °C	S_t/S_{e35}	p
	G	
200	48.5	
203	30.8	
210	20.8	
214	15.2	
	Sat. vap.	
87	0.235	
125.2	0.73	
137	1.20	
145	1.95	2.5
149	2.10	
154	2.42	
155.4	2.66	
167	3.90	2.0
172	5.88	
183	13.4	1.5
187	17.8	
189	22.1	
190.5	23.3	
193	30.8	
196	70.8	1.5

C_5H_{12}.—*(Cont'd)*

t, °C	S_t/S_{e35}	p
	Liquid	
36.5	1.61	7.2
80		7.2
86.6	2.84	6.7
103.8	3.40	
117.0	4.25	5.2
128.0	5.36	5.2
138.0	6.37	
148.6	8.18	1.7
156.8	9.10	1.5
173		1.5

C_6H_6, Benzene

	Sat. vap. (32)	
35		7.2
100		6.2
182	0.95	3.5
204	1.56	3.4
228	3.00	2.5
247	4.9	2.0
267	11.9	1.5
280		0.9

C_6H_6.—*(Cont'd)*

t, °C	S_t/S_{e35}	p
	Liquid (32)	
35	3.2	43
125	3.67	32
182	5.48	19
205	7.21	14
228	11.0	9.5
268	20.5	3.0
283	102	2.8

t, °C	S_t/S_{20}	p
	Liquid (25)	
0		49†
5		48‡
10		48
20	1.00	49
100	1.33	39
200	2.40	15.4
250	6.0	6.1
260	10.7	4.5
270	19.4	2.5
280	62.0	1.5

†Under-cooled. ‡ M.P.

C_7H_{16}, Heptane

t, °C	S_t/S_{20}	p
	Liquid (25)	
20	1.00	12.7
100	1.30	10.0
200	3.97	3.8
225	6.8	2.6

C_7H_{16}.—*(Cont'd)*

t, °C	S_t/S_{20}	p
	Liquid (25)	
240	10.1	2.0
250	13.4	1.7
260§	16.8	1.65
270§	28.1	1.55

$C_{10}H_8$, Naphthalene

t, °C	S_t/S_{80}	p
	Liquid (25)	
80	1.00	71.0
200	1.04	63.5
300	1.30	41.0

§ At critical temperature S_t/S_{20} is very great.

LITERATURE

(For a key to the periodicals see end of volume)

(1) Aschkinass, *8*, **55**: 401; 95. (2) von Aufsess, *Diss.*, Munich, 1903. (3) Bhattacharyya, *512*, **8** IV: 277; 23. (4) Blondel, *Éclairage Électrique*, **3**: 583; 95. (5) Cabannes, *34*, **160**: 62; 15. (6) Cabannes, *34*, **171**: 852; 20. (7) Cabannes, *16*, **15**: 5; 21. (8) Cabannes, *51*, **3**: 429; 22. (9) Cabannes and Gauzit, *51*, **6**: 182; 25.

(10) Cabannes and Granier, *51*, **4**: 429; 23. (11) Cabannes and Lepape, *34*, **179**: 325; 24. (12) Channon, Renwick and Storr, *5*, **94**: 222; 17. (13) Coblentz, *31*, **16**: 701; 20. (14) Ewan, *5*, **57**: 117; 95. (15) Ganesan, *2*, **23**: 63; 24. (16) Ganesan, *3*, **49**: 1216; 25. (17) Gans, *8*, **65**: 97; 21. (18) Gans, *96*, **17**: 353; 23. (19) Ives and Kingsbury, *84*, **9**: 795; 14. **10**: 253; 15.

(20) Krishnan, *3*, **50**: 697; 25. (21) Luckiesh, *107*, **60**: 1040; 12. **61**: 883; 13. (22) Martin, *50*, **24**: 478; 20. (23) Martin, *50*, **28**: 1284; 24. (24) Martin and Lehrman, *50*, **26**: 75; 22. (25) Martin and Lehrman, *50*, **27**: 558; 23. (26) Narayan, *67*, **36**: 32; 23. (27) Nutting, *84*, **11**: 92; 16. (28) Raman and Ramanathan, *5*, **104**: 357; 23. (29) Raman and Rao, *3*, **45**: 625; 23.

(30) Raman and Rao, *3*, **46**: 426; 23. (31) Ramanathan, *5*, **102**: 151; 22. (32) Ramanathan, *2*, **21**: 564; 23. (33) Ramanathan, *5*, **110**: 123; 26. (34) Ramanathan and Srinivasan, *3*, **1**: 491; 26. (35) Rav, *2*, **22**: 78; 23. (36) Rayleigh, *5*, **97**: 435; 20. (37) Rayleigh, *5*, **98**: 57; 20. (38) Rocard, *34*, **180**: 52; 25. (39) Sharp and Little, *84*, **10**: 727; 15.

(40) Strutt, *5*, **95**: 155; 18. (41) Venkataswaran, *4*, **121**: 2655; 22.

SPECTRAL ABSORPTION OF LIGHT AND HEAT BY PURE INORGANIC SUBSTANCES AND MISCELLANEOUS MATERIALS (NONMETALS)

JEAN BECQUEREL AND J. ROSSIGNOL

Order of Substances.—Atmospheric air, elementary substances, pure inorganic compounds, minerals of variable composition.

ABSORPTION OF ATMOSPHERIC AIR

w = equivalent thickness of liquid H_2O in a column of air 117 m long (P = 1 atm., $t < 40$°C) = volume of liquid H_2O obtained by condensing the H_2O vapor contained in a column of air of unit sectional area and 117 m long. O = opacity of the atmosphere (source of light at zenith) = I_i/I_g; $I_i[I_g]$ = intensity of radiation beyond atmosphere [at surface of earth]. $I = I_0 e^{-kl(10)^n}$; l = length of path in which intensity is reduced from I_0 to I. All I's refer to radiant energy, not to its visibility.

Unit of $k(10)^n = 1\ \mathrm{cm}^{-1}$; of $l = 1$ cm; of $w = 1$ cm; of $\lambda = 1\mu = 10^4$Å $= 10^{-4}$ cm.

λ	k	
Dry air (12), $w = 0$, $n = -3$		
0.186	4.82	
Moist air (7), $n = -5$		
w	0.008	0.082
λ	k	k
1.3 to 1.75	0.54	1.7
1.75 to 2.2	1.25	2.9
2.2 to 3.2	2.3	4.5

w	0.008	0.082
λ	k	k
3.2 to 4.0	2.1	3.95
4.0 to 4.9	3.3	5.9
4.9 to 5.4	1.7	4.7
5.4 to 5.9	5.4	16
5.9 to 6.4	8.7	30
6.4 to 7.0	9.8	30
7.0 to 8.0	2.5	8.3

Moist air (7), $n = -5$

w	0.003	0.03	0.3	3.0
λ	k	k	k	k
3 to 4	0.9	3.05	5.9	12
4 to 5	1.4	5.1	10.3	26
5 to 6	1.5	4.8	9.2	26
6 to 7	5.1	16	26	>40
7 to 8	1.2	4.7	16	>40
8 to 9	< 0.1	0.17	4.4	5.9
9 to 10	< 0.1	< 0.1	< 0.1	1.4
10 to 11	< 0.1	0.17	0.44	4.4
11 to 12	< 0.1	< 0.1	0.35	0.9
12 to 13	< 0.1	< 0.1	1.2	1.9
13 to 16	>40	>40	>40	>40
16 to 20	20	>40	>40	>40
20 to 30	10(?)	14(?)	20(?)	>40
30 to 40	>40(?)	>40(?)	>40(?)	>40
40 to 50	>40	>40	>40	>40

Opacity of atmosphere* (6)

λ	$\log_{10} O$	λ	$\log_{10} O$	λ	$\log_{10} O$
0.2898	6.36	0.2931	4.36	0.2997	2.22
.2906	5.78	.2936	4.12	.3022	1.77
.2912	5.39	.2946	3.73	.3052	1.40
.2917	5.08	.2956	3.33	.3104	0.99
.2922	4.82	.2963	3.10	.3143	0.84

* Average conditions, no clouds, value of w is not indicated.

ABSORPTION OF PURE NON-METALLIC INORGANIC SUBSTANCES AND MINERALS

$I = I_0e^{-kl(10)^n}$, l = length of path in which intensity is reduced from I_0 to I; I and I_0 refer to radiant energy, not to its visibility; d = density. For metals, *v.* p. 248.

Unit of $k(10)^n = 1\ \text{cm}^{-1}$; of $l = 1$ cm; of $P = 1$ mm of Hg; of $d = 1\ \text{g cm}^{-3}$; of $\lambda = 1\mu = 10^4\text{Å} = 10^{-4}$ cm; t is °C.

Br $(^{24})$, $t = 16°$, $P = 66$, $n = -2$

λ	k
0.356	10.6±0.1
.3641	22.4±0.2
.3713	38.9±0.4
.3838	75.3±0.8
.3900	98 ±1
.4009	129 ±1
.4070	136 ±1
.421	135 ±1
.433	128 ±1
.449	112 ±1
.487	76 ±4
.510	57 ±3
.526	38 ±2
.546	23 ±1
.572	12.1±0.6
.608	3.1±0.2
t = 320°,	
0.354	21.3±0.4
.377	65 ±1
.406	115 ±2
.428	122 ±2
.439	115 ±2
.471	85 ±2

Br.—(*Cont'd*)

λ	k
0.510	51 ±1
.557	19.6±0.4
t = 620°	
0.344	18.3±0.4
.358	37.6±0.8
.379	74 ±1
.395	97 ±2
.420	113 ±2
.433	113 ±2
.459	97 ±2
.484	74 ±1
.530	37.9±0.8
.577	16.3±0.3

C, Diamond $(^{22})$*

0.226	1477
.231₅	678
.255	74±1
.275	59±1
.300	43±1
.320	32±1
.350	21±2
.380	15±1
.400	12

C.—(*Continued*)

λ	k
0.430	11
.550	<1
.600	3

C, Graphite $(^{37})$†

0.430	1455±25
.450	1410±25
.500	1305±25
.550	1225±20
.600	1155±20
.650	1110±15
.700	1070±15

C, Amorphous $(^{30})$†

0.430	198.0±1.0
.450	188.0±1.0
.480	174.5±1.0
.500	166.0±1.0
.530	155.5±1.5
.550	149.5±1.5
.580	141.5±1.0
.600	137.0±1.0
.630	131.5±0.5

* $n = -2$. † $n = +3$.

Cl, $t = 0°$, $P = 760$, $n = -2$

λ	k $(^{21})$	k $(^{10})$	k $(^{24})$	λ	k $(^{21})$	k $(^{10})$	k $(^{24})$
0.226	62			0.338			568±11
.230	62			.340	527		
.235	62			.346			529±10
.245	43			.350	477		
.250	43			.3525			456± 9
.254		2.5		.3593			366± 7
.255	50			.360	422		
.260	60			.365			280± 6
.265		12.8		.366		284	
.270	80			.370	370		
.275	93			.373			192± 4
.280	123	77.1		.380	212		
.285	157			.381			130± 2
.289		74.8		.385	158		
.290	187			.390	183		
.295	211			.405	277	41.6	
.297		278		.410	211		
.300	300			.411			3.7±0.1
.303		367		.435	117		
.310	415			.436		17.1	
.313		571		.472		4.2	
.3142			129± 2	.480		2.4	
.3192			225± 4	.496		1.05	
.320	508			.509		0.47	
.321			315± 6	.545	61		
.3238			445± 9	.546		0.018	
.327			529±10	.579		0.003	
.330	560			.580	82		
.331			565±11	.614		0.51	
.334		684		.643		0.41	

I, Solid $(^{17})$, $n = +3$

λ	k
0.325	318
.360	462
.400	466
.440	437
.470	384
.510	300
.590	120

I, Gas $(^{32})$, $n = -2$

t	48°	88°	400°
10 000d	0.254	2.5	2.5
λ	k	k	k
0.440	0.8		
.445	4.0		
.450	6.5		19
.455	9		23
.460	10	13	27
.465	12	17	32
.470	13	22	37
.475	15	29	45
.480	16	40	55
.485	17	54	64
.490	19	64	68
.495	20	71	71
.500	21	75	72
.505	20	77	71
.510	19	76	68
.515	16	68	60
.520	14	52	48
.525	13	42	38
.530	13	36	35
.535	13	32	34
.540	14	29	34
.545	14	27	33
.550	14	26	31
.555	15	25	29
.560	15	24	26
.565	14	23	23
.570	13	22	21
.575	11	21	20
.580	9	20	19
.585	8	18	20
.590	7	16	20
.595		14	

$N_2$$(^{12})$, $t = 0°$, $P = 760$, $n = -5$

λ	k
0.186	109

$O_2$$(^{12})$, $t = 0°$ $P = 760$, $n = -3$

0.186	20.6
0.193	3.35

O_2, $P = 760$ $(t + 273)/273$, $n = 0$$(^{35})$

t	1220°	1400°
λ	k	k
0.210	0.33	0.73
.220	0.26	0.50
.230	0.19	0.32
.239	0.13	0.22
.254	0.06	0.13
t	1580°	1760°
λ	k	k
0.210	>4.5	>4.5
.220	0.92	1.77
.230	0.54	0.97
.239	0.37	0.67
.254	0.21	0.42

O_3, Ozone, $t = 0°$, $P = 1$, $n = 0$

λ	k $(^{19})$	k $(^{13})$	k $(^{5})$
0.193	26.9		
.200	17.9		
.210	26.4		
.220	44.3		
.230	112		115
.240	241	260	219
.250	284	374	276
.254		430	
.260	291		276
.265		341	
.270	267	174	209
.280	169	112	106
.290	89	56	38
.300	69.8	18	10.6
.310			2.83
.320			0.81
.330			0.21
.340			0.06

S, Gas $(^{11})$, $t = 450°$, $d = 67 \times 10^{-6}$, $n = -2$

λ	k
0.435	27
.460	20
.500	15
.550	7
.610	<0.5

Se, Vitreous, $n = +3$

λ	k $(^{36})$	k $(^{17})$
0.260		613
.275		611
.300		652
.325		580
.360		480
.400	726	380
.415	660	
.425	594	
.440	525	300
.470	460	252
.490	382	
.510		203
.515	273	
.550	176	
.590	95.5	170
.640	47.1	
.670		84
.710	21.4	
.760	10.1	

Se, Gas $(^{11})$, t = 700°C, $d = 10.9 \times 10^{-5}$, $n = -2$

λ	k
0.435	43
.450	39
.510	23
.525	19
.580	<0.5

H_2O, Gas $(^{3})$, $t = 0°$, $P = 760$, $n = -3$

1.35	4.6
1.37	8.7

H_2O.—(*Cont'd*)

λ	k
1.404	19.3
1.45	11.4
1.50	4.2
1.80	3.7
1.85	18.7
1.885	25.8
1.935	18.8
1.97	12.0
2.0	3.6
2.55	25.8
2.585	64.4
2.618	90
2.65	59

H_2O, Liquid $(^{12})$, $n = -2$

0.186	68.8
.193	16.6
.200	9.0
.210	6.1
.220	5.7
.230	3.4
.240	3.2
.260	2.5
.300	1.5

$n = -3$

λ	k $(^{1})$	k $(^{4})$	k $(^{2})$
0.415		0.35	
.420		0.32	
.430*		0.23	
.440		0.16	
.450	0.20	0.12	
.460		0.11	
.470		0.12	
.480	0.20	0.13	
.490		0.14	0.02
.500	0.20	0.15	
.510	0.22	0.16	
.520	0.18	0.18	0.02
.530	0.08	0.19	0.03
.540*	0.09	0.21	0.11
.550	0.36	0.23	0.26
.560	0.30	0.27	0.40
.570	0.20	0.33	0.43
.580*	0.26	0.42	0.50
.590	0.78	0.70	0.89
.600	1.60	1.07	1.65
.610	1.90	1.18	2.20
.620	2.12	1.24	2.40
.630	2.24	1.30	2.50
.640	2.35	1.37	2.75
.650	2.50	1.48	3.05
.660	2.80	1.62	3.25
.670	3.00	1.83	
.680	3.40	2.10	
.690	4.00	2.50	
.700	5.50	3.00	
.710	7.90	3.90	
.720	11.5	4.70	
.730	17.5	5.70	
.740	23.0		
.75	24.1		
.80	20.4	$(^{3})$	
.85		69	
.90		161	
.95		311	
.995	416	472	
1.05		368	

* Liquid H_2O, $(^{16})$ $n = -3$.

λ	0.4358	0.5461	0.5780
k	0.12	0.34	0.64

H_2O.—(*Cont'd*)

$n = 0$

λ	k (1)	k (3)
1.05		0.368
1.085		0.333
1.095	0.188	
1.13		0.60
1.17		1.12
1.21		1.30
1.243	1.22	
1.25		1.24
1.281	1.17	
1.30		1.48
1.35		2.14
1.40		3.05
1.45		20.1
1.475		29.9
1.50	38.4	26.4
1.56		15.0
1.60		9.2
1.677		5.2
1.708	11.4	
1.75		7.5
1.85		12.7
1.90		31.5
1.95		86
1.956	123	
1.97		104
2.00		70
2.08		35.6
2.10		31.6
2.147	27.8	
2.15		24.7
2.237		19.6
2.30		25.9
2.35		33.0
2.40		40.3

$n = +2$

λ	k (1)	k (9)
2.6		5.32
2.8		22.4
3.0		73.3
3.02	27.3	
3.2		66.4
3.4		14.4
3.6		4.9
3.93	2.04	
4.5		4.47
4.70	5.45	
5.27	3.08	
5.42	3.42	
5.47	3.35	
5.8		9.1
6.0		21.4
6.09	25.3	
6.2		20.0
6.5		10.3
6.73	8.7	
6.765	8.8	
6.92	8.2	
6.955	8.3	
7.0		8.9
7.11	8.2	
7.275	8.45	
7.41	7.9	
7.44	8.1	
7.49	8.0	
7.545	8.1	
7.65	7.65	
7.70	7.85	
7.83	7.65	
7.88	7.75	
7.94	6.9	
8.0		7.55
8.065	7.85	
8.13	7.65	
8.16	7.85	
8.22	7.15	
8.28	7.65	
8.38	6.95	
8.43	7.55	
8.49	7.25	
9.0		7.0
10.0		7.05

H_2O.—(*Cont'd*)

λ	k (1)	k (9)
11.0		12.0
12.0		25.9
13.0		28.9
15.0		35.7
18.0		29.9
	(25)	
24	>0.46	
52	>0.46	
61	>0.46	(20)
108		4.23
314		2.42

HBr, Gas (33); *cf.* (38)

$t = 0°$, $P = 760$,

$n = -3$

λ	k
0.207	44.4
.253	3.20

HI, Gas (34); *cf.* (38)

$t = 0°$

$P = 760$, $n = -3$

0.207	62.2
.253	29.0

SO_2, Gas (8), $t = 0°$,

$P = 760$, $n = 0$

0.220	57
.2225	18.5
.280	32
.285	35.5
.290	39.5
.295	42.5
.300	41
.305	34
.310	20
.315	6.3
.320	4.0

NO, Gas (12), $t = 0°$,

$P = 760$, $n = -3$

0.200	142.2
.210	95.1
.220	84.1
.230	52.1
.240	24.0
.250	3.18
.300	0.80

CO_2, Gas (12), $t = 0°$,

$P = 760$, $n = -3$

0.186	7.64
.193	2.13
.200	0.95

$n = -3$ (29)

1.96	0.3
2.12	0.3
2.28	0.03
2.40	1.7
2.50	5.7
2.60	11.5
2.70	13.4
2.80	11.4
2.90	6.5
3.00	2.7
3.10	1.1
3.20 3.80	< 0.01
3.90	1.3
4.0	4.1

CO_2.—(*Cont'd*)

λ	k
4.10	12.0
4.20	33.5
4.25	50
4.30	61
4.33	63
4.35	60
4.40	38
4.45	27
4.50	20
4.60	11.2
4.69	1.2

CS_2, Liquid (25),

$n = 0$

24	5.1
52	0.20
61	0.30

λ **SiO_2**, *v.* Vol. VI

AgCl (25), $n = 0$

24	4.8
52	>27
61	>27

AgBr, Fused (31),

$n = +3$

0.360	6.7
.370	5.0
.380	3.8
.390	2.79
.400	2.00
.410	1.38
.420	0.90
.430	0.60
.440	0.41
.450	0.27

AgI (28), $n = +3$

λ	k
0.215	85.3 ± 1.9
.220	88.0 ± 2.0
.225	87.7 ± 2.0
.230	88.5 ± 2.0
.235	88.8 ± 2.0
.240	96.3 ± 2.1
.245	99.5 ± 2.1
.250	102 ± 2
.255	104 ± 2
.260	113 ± 2
.265	138 ± 3
.270	276 ± 6
.2712	282 ± 6
.275	259 ± 5
.280	235 ± 5
.285	220 ± 4
.290	208 ± 4
.295	198 ± 4
.300	188 ± 4
.305	179 ± 4
.310	171 ± 4
.315	167 ± 4
.3191	167 ± 4
.320	167 ± 4
.325	165 ± 4
.330	158 ± 3
.335	144 ± 3
.340	124 ± 3
.345	117 ± 2

AgI.—(*Cont'd*)

λ	k
0.350	111 ± 2
.355	104 ± 2
.360	101 ± 2
.365	98 ± 2
.370	95 ± 2
.375	93 ± 2
.380	90 ± 2
.385	88 ± 2
.390	87 ± 2
.395	86 ± 2
.400	85 ± 2
.405	85 ± 2
.410	88 ± 2
.415	101 ± 2
.420	128 ± 3
.4227	138 ± 3
.425	117 ± 2
.430	33 ± 10
.435	10 ± 3
.440	5.1 ± 1.5
.445	3.1 ± 1.0
.450	1.1 ± 0.3

Fe_3O_4, Magnetite

(14), $n = +3$

λ	k
0.440	242
.460	222
.480	201
.500	183
.520	169
.540	158
.560	150
.580	145
.600	138
.620	133
.640	126
.660	118
.680	109
.700	98

$Fe_2O_3.CuO$, Cuproferrite (14), $n = +3$

0.440	270
.460	230
.480	200
.500	179
.520	162
.540	145
.560	118
.580	90
.600	80
.620	72
.640	64
.660	55
.680	47
.700	38

CaF_2, Fluorite

$n = 0$ (23)

0.186	0.22

$n = 0$ (26)

6	<0.01
8	0.17
9	0.61
10	1.8
11	4.6
12	>7

CaF_2.—(*Cont'd*)

λ	k
	$n = 0$ (25)
24	>8.5
52	5.7
61	5.02

$CaCO_3$, Calcite

$n = 0$ (23)

0.215	3.36
.230	1.25
.240	0.58
.250	0.40
.260	0.29
.270	0.20
.280	0.16

k_o†, $n = 0$ (18)

1.02	0.00
1.25	0.00
1.45	0.00
1.72	0.03
2.07	0.13
2.11	0.74
2.30	1.92
2.44	3.00
2.53	1.92
2.60	1.21
2.65	1.74
2.74	2.36
2.83	1.32
2.90	0.70
2.95	1.80
3.04	4.71
3.30	22.7
3.47	19.4
3.62	9.6
3.80	18.6
3.98	∞
4.35	6.6
4.52	14.3
4.66	11.6
4.83	6.1
5.25	8.0

k_e†, $n = 0$ (18)

2.49	0.14
2.87	0.08
3.00	0.43
3.28	1.32
3.38	0.89
3.59	1.79
3.76	2.04
3.90	1.17
4.02	0.89
4.41	1.07
4.67	2.40
4.91	1.25
5.04	2.13
5.34	4.41
5.50	12.8

†k_o for ordinary and k_e for extraordinary ray.

NaCl, Rock salt

$n = 0$ (23)

0.186	0.36
.210	0.26
.231	0.15
.280	0.046

NaCl.—(*Cont'd*)

λ	k
	$n = 0$ (27)
6 to 8	<0.001
9 to 11	0.005
12	0.007
13	0.024
14	0.071
15	0.167
16	0.41
17	0.66
18	1.29
19	2.34
20.7	5.1

$n = 0$ (25)

24	10.7
52	>16
61	>16

KCl, Sylvite

$n = 0$ (27)

10	0.012
11	0.010
12	0.005
13	0.005
14	0.025
15	0.047
16	0.066
17	0.081
18	0.148
19	0.277
20.7	0.535
24	1.86

Biotite (15), $n = 0$,

$t = 25°$

1.52	42.0
1.82	19.0
2.25	8.1
2.76	6.8
2.91	6.2
2.96	6.1
3.0	4.7
3.04	4.6
3.12	4.2
3.22	3.4
3.85	3.6
4.06	3.8

$n = 0$, $t = 250°$

1.50	63
1.80	42
2.21	34
2.72	22
2.92	19
3.0	17
3.19	16
3.4	13
3.6	12
3.8	10
4.01	11

Mica

$n = +2$ (25)

24	1.8
52	3.2
61	3.0

$n = +2$ (20)

108	3.3
314	1.1

LITERATURE

(For a key to the periodicals see end of volume)

(1) Aschkinass, *8*, **55**: 401; 95. (2) d'Aufsess, *8*, **13**: 678; 04. (3) Dreisch, *96*, **30**: 200; 24. (4) Ewan, *3*, **33**: 317; 92. (5) Fabry and Buisson, *34*, **156**: 782; 13. (6) Fabry and Buisson, *51*, **2**: 197; 21. *21*, **54**: 297; 21. (7) Fowle, *302*, **68**: No. 8; 17. (8) Garrett, *3*, **31**: 505; 16. (9) Goldhammer, *Dispersion und Absorption des Lichtes*. Leipsig, Teubner, 1913.

(10) Halban and Siedentopf, *7*, **103**: 71; 22. (11) Koenigsberger and Küpferer, *8*, **37**: 601; 12. (12*) Kreusler, *8*, **6**: 412: 01. (13) Krüger and Moeller, *63*, **13**: 729; 12. (14) Loria and Zakrzewski, *180*, **1910A**: 278. *10*, **1**: 93; 10. (15) Martin, *6*, **96**: 185; 19. (16) Martin, *50*, **26**: 471; 22. (17) Meier, *8*, **31**: 1017; 10. (18) Merritt, *2*, **2**: 424; 95. (19) Meyer, *8*, **12**: 849; 03.

(20) Owen, *121*, **68**: 504; 12. (21) Peskov, *53*, **47**: 918; 15. (22) Peter, *96*, **15**: 358; 23. (23) Pflüger, *63*, **5**: 215; 04. (24) Ribaud, *6*, **12**: 107; 19. (25) Rubens and Aschkinass, *8*, **65**: 241; 98. (26) Rubens and Nichols, *2*, **4**: 314; 97. (27) Rubens and Nichols, *2*, **5**: 98; 97. (28) Schell, *8*, **35**: 695; 11. (29) Schmidt, *8*, **42**: 415; 13.

(30) Senftleben and Benedict, *8*, **54**: 65; 17. (31) Slade and Toy, *5*, **97**: 181; 20. (32) Vogt and Koenigsberger, *96*, **13**: 292; 23. (33) Warburg, *76*, **1916**: 314. (34) Warburg, *76*, **1918**: 300. (35) von Wartenberg, *63*, **11**: 1168; 10. (36) Wood, *3*, **3**: 607; 02. (37) Zakrzewski, *180*, **1910A**: 116. *10*, **1**: 93; 10. (38) Tingey and Gerke, *1*, **48**: 1838; 26.

* Errors in computation have been corrected by Becquerel and Rossignol.

SPECTRAL FILTERS

K. S. GIBSON

The filters here considered cover the spectral regions commonly designated as ultra-violet (UV), visible (v), and infra-red (IR). The numerical data are based on quantitative measurements, but, owing to the variability of much of the material or to the insufficiency of the details given by the authors, they are, in general, to be considered as illustrative only. As a rule, only such glasses, crystalline material, and simple, well-known substances as have a relatively sharp transition between the regions of free transmission and of strong absorption are noted. Many of these filters, especially those having selective transmission between $\lambda = 0.3\mu$ and 0.7μ, can be practically duplicated by means of dyes and other solutions.

Filters

Spectral filters may conveniently be divided into three classes:

Class 1.—Strong absorption if λ is less than a certain value, λ_c, and free transmission over a wide adjacent range where $\lambda > \lambda_c$.

Radiation in range $0.002\mu < \lambda < 0.12\mu$ is not transmitted by any solid or liquid; of ordinary gases, H_2 is the most and O_2 is the least transparent in this region (31). The UV-limit of transmission of air is near that of H_2O (λ_c of W_1, *ca.* $\lambda = 0.17\mu$) (31). Curves similar to those of Fig. 1 may be obtained between 0.2μ and 0.35μ by use of organic liquids (1, 2, 47), between 0.3μ and 0.7μ by use of solutions or of dyed films of gelatin (15), and in IR (4, 43, 46) by use of thin layers of lampblack or various thicknesses of black paper or cardboard.

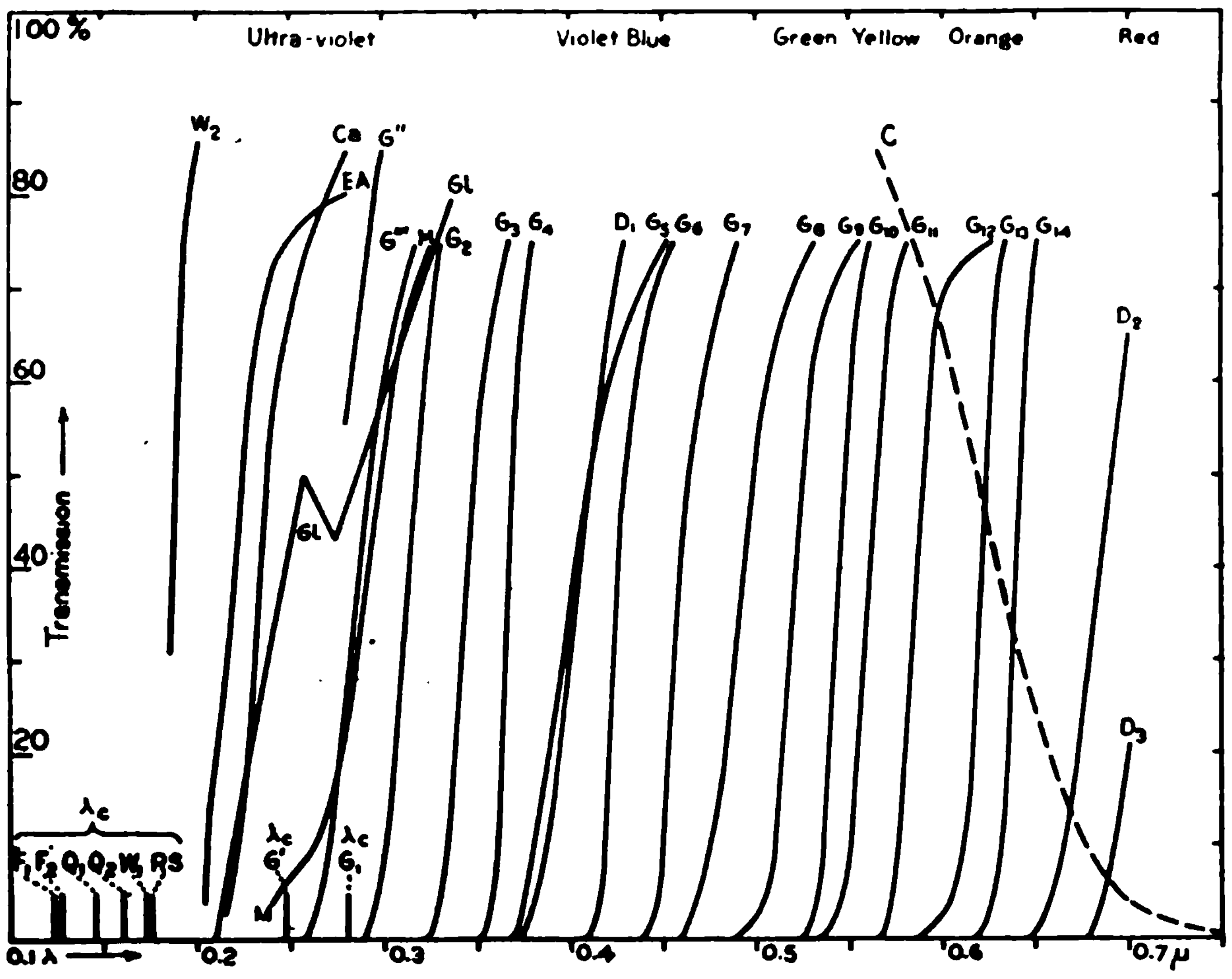

FIG. 1.—Filters of Class 1: Transmission near λ_c.

For descriptions of filters, *see* Table 1; C is of Class 2. For F_1, F_2, Q_1, Q_2, W_1, RS, G′ and G_1, only value of λ_c is indicated; curves for C, Ca, EA, G″, Gl and W_2 have been corrected for surface and window losses (reflection and absorption), other curves are uncorrected. $0.1\mu = 10^{-5}$ cm = 1000 Å.

Class 2.—Strong absorption over wide region in which λ is greater than λ_c, and free transmission over a wide adjacent range for which $\lambda < \lambda_c$.

For the substances considered here, the long wave-length boundary of the absorption lies far in the IR, but transmission at still greater values of λ may be of much importance. For summary of such data, and bibliography to 1921, *see* (46). Crystalline SiO_2 is notably transparent if $\lambda > 50\mu$; if sufficiently thin, many substances transmit if $\lambda >$ *ca.* 100μ, and there is considerable transmission through 1 mm of CaF_2, KCl, NaCl, and amorphous SiO_2, but there seems to be no transmission through this thickness of H_2O or of glass.

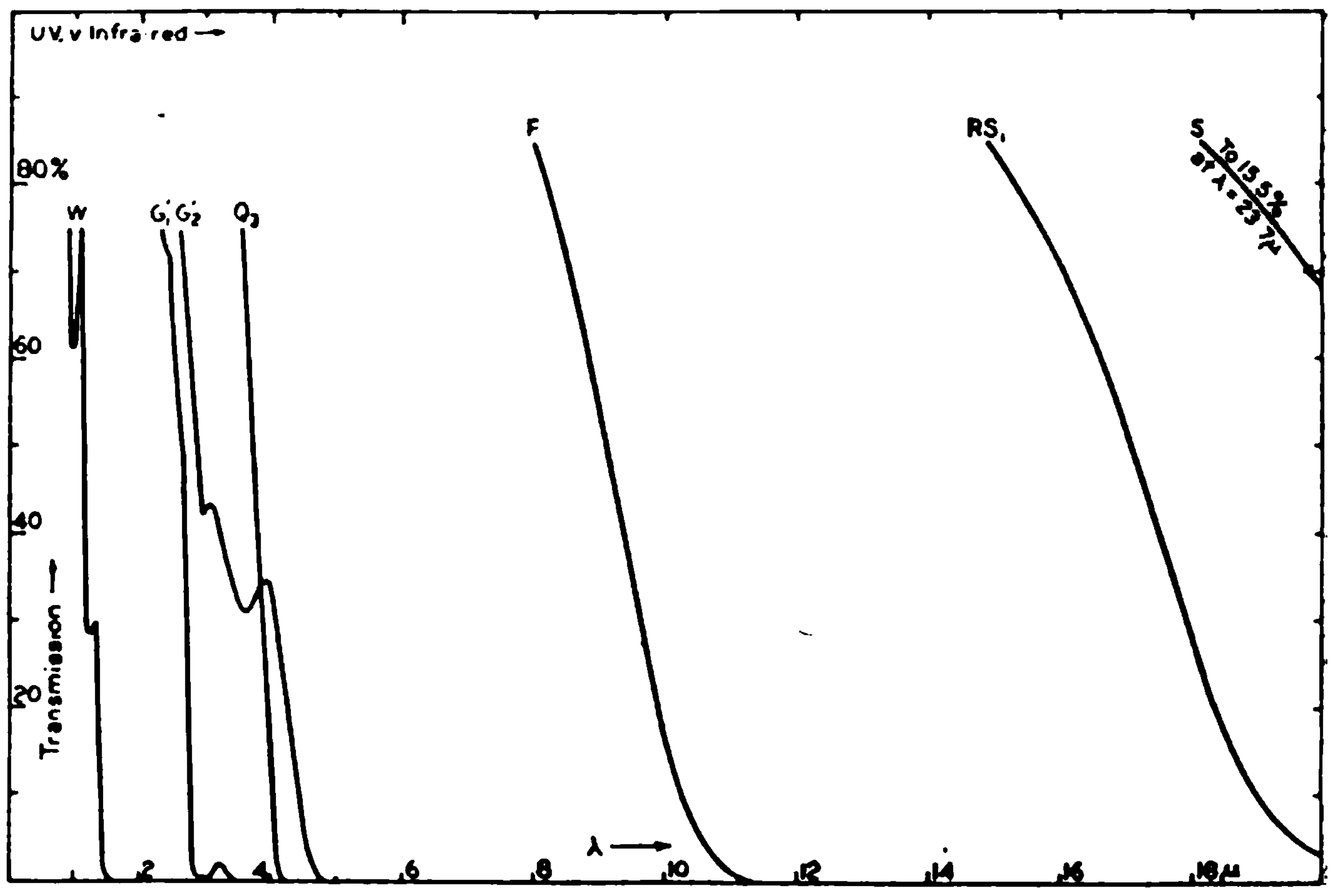

FIG. 2.—Filters of Class 2: Transmission near λ_c.

See also C of Fig. 1. For description of filters, *see* Table 1. Curves for F, RS, and S have been corrected for reflection at surfaces, others are uncorrected. $1\mu = 10^{-4}$ cm = 10 000 Å.

Aqueous (H_2O) solutions of Cu salts completely absorb the IR while freely transmitting the visible spectrum (*cf.* C, Fig. 1); at least 2 cm of the solution should be used (6, 19). For glasses which visually approximate filter C, *see* (16, 20, 22); they all transmit some IR (11, 12). For isolating the region $\lambda < 0.3\mu$, *see* Class 3.

Class 3.—Strong absorption except over certain narrow regions of the spectrum.

In Figs. 3, 4 and 5 are shown the transmissions of certain filters of this class. By a suitable choice of these filters, assisted by those of classes 1 and 2 as may be necessary, it is possible to isolate any one of many narrow spectral regions (19). No known filter transmits only the region $\lambda < 0.3\mu$; the best consists of quartz (SiO_2) cells filled with Cl and Br gas (37); *see* Fig. 3. For transmission of Cl, *see also* (24, 36), of Br (49). Aqueous solutions of acetone (C_3H_6O) (1), of *p*-nitrosodimethylaniline ($C_8H_{10}N_2O$) (37, 45), etc., may assist in isolating the UV, especially when presence of radiation at $\lambda > 0.5\mu$ can be ignored, as in usual photographic work. *See also* Fig. 4 and Special Filters, 4.