GCE A LEVEL

1410U40-1A

TUESDAY, 18 JUNE 2024 – MORNING

CHEMISTRY – A2 unit 4

DATA BOOKLET

Avogadro constant	N_A	=	$6.02 \times 10^{23}\ \text{mol}^{-1}$
molar gas constant	R	=	$8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
molar gas volume at 273 K and 1 atm	V_m	=	$22.4\ \text{dm}^3\ \text{mol}^{-1}$
molar gas volume at 298 K and 1 atm	V_m	=	$24.5\ \text{dm}^3\ \text{mol}^{-1}$
Planck constant	h	=	$6.63 \times 10^{-34}\ \text{J s}$
speed of light	c	=	$3.00 \times 10^{8}\ \text{m s}^{-1}$
density of water	d	=	$1.00\ \text{g cm}^{-3}$
specific heat capacity of water	c	=	$4.18\ \text{J g}^{-1}\ \text{K}^{-1}$
ionic product of water at 298 K	K_w	=	$1.00 \times 10^{-14}\ \text{mol}^2\ \text{dm}^{-6}$
fundamental electronic charge	e	=	$1.60 \times 10^{-19}\ \text{C}$

temperature (K) = temperature (°C) + 273

$1\ \text{dm}^3 = 1000\ \text{cm}^3$

$1\ \text{m}^3 = 1000\ \text{dm}^3$

1 tonne = 1000 kg

$1\ \text{atm} = 1.01 \times 10^5\ \text{Pa}$

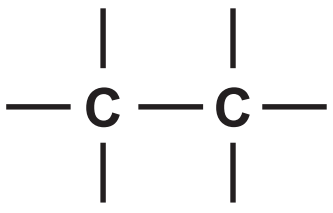
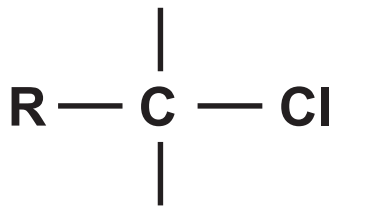
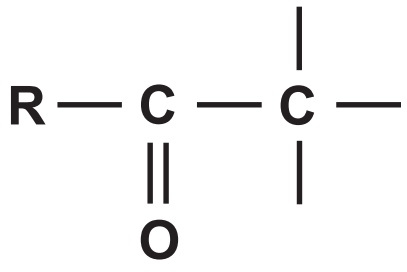
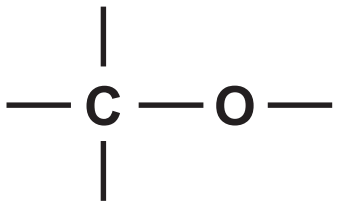
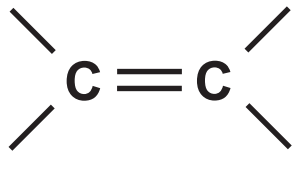
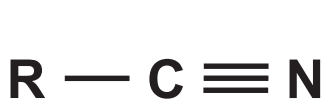
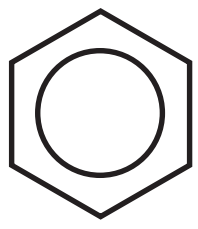
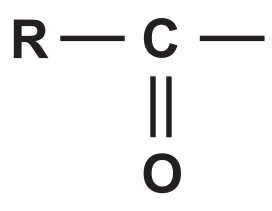
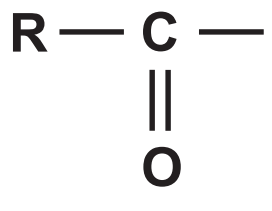
Multiple	Prefix	Symbol
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

Multiple	Prefix	Symbol
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G

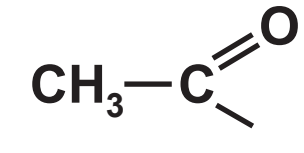
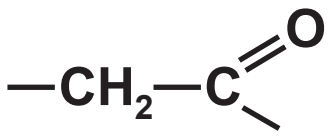
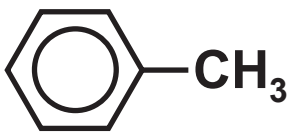
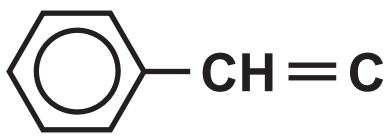
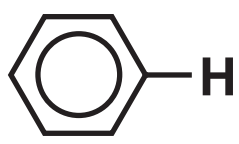
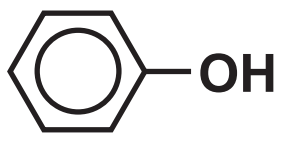
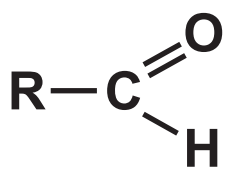
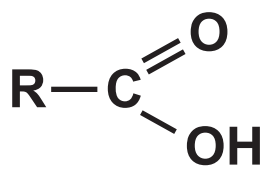
INFRARED ABSORPTION VALUES

BOND	WAVENUMBER / cm^{-1}
C — Br	500 to 600
C — Cl	650 to 800
C — O	1000 to 1300
C ═ C	1620 to 1670
C ═ O	1650 to 1750
C ≡ N	2100 to 2250
C — H	2800 to 3100
O — H (carboxylic acid)	2500 to 3200 (very broad)
O — H (alcohol / phenol)	3200 to 3550 (broad)
N — H	3300 to 3500

^{13}C NMR CHEMICAL SHIFTS RELATIVE TO TMS = 0

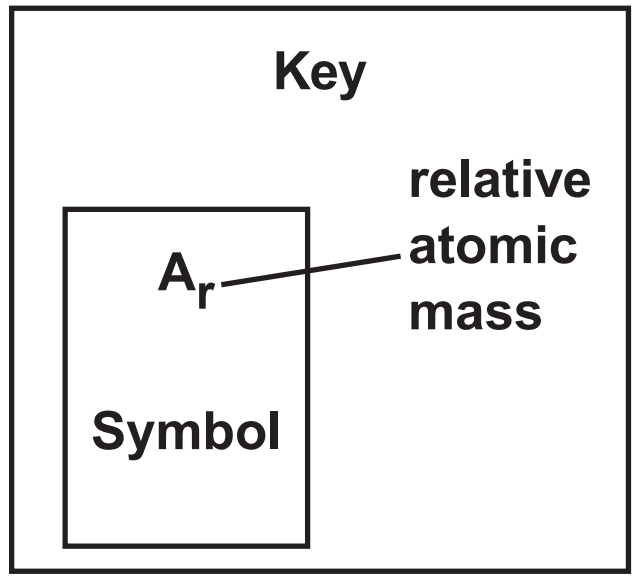
TYPE OF CARBON	CHEMICAL SHIFT, δ (ppm)
	5 to 40
	10 to 70
	20 to 50
	25 to 60
	50 to 90
	90 to 150
	110 to 125
	110 to 160
 (carboxylic acid / ester)	160 to 185
 (aldehyde / ketone)	190 to 220

^{1}H NMR CHEMICAL SHIFTS RELATIVE TO TMS = 0

TYPE OF PROTON	CHEMICAL SHIFT, δ (ppm)
$-CH_3$	0.1 to 2.0
$R-CH_3$	0.9
$R-CH_2-R$	1.3
$CH_3-C\equiv N$	2.0
	2.0 to 2.5
	2.0 to 3.0
	2.2 to 2.3
HC—Cl or HC—Br	3.1 to 4.3
HC—O	3.3 to 4.3
R—OH	4.5 *
$-C=CH$	4.5 to 6.3
$-C=CH-CO$	5.8 to 6.5
	6.5 to 7.5
	6.5 to 8.0
	7.0 *
	9.8 *
	11.0 *

*variable figure dependent on concentration and solvent

THE PERIODIC TABLE



Period	1	2	Group 3	4	5	6	7	0
	s Block							
1	1.01 H							4.00 He
						p Block		
2	6.94 Li	9.01 Be	10.8 B	12.0 C	14.0 N	16.0 O	19.0 F	20.2 Ne
3	23.0 Na	24.3 Mg	27.0 Al	28.1 Si	31.0 P	32.1 S	35.5 Cl	40.0 Ar
			d Block					
4	39.1 K	40.1 Ca	45.0 Sc	47.9 Ti	50.9 V	52.0 Cr	54.9 Mn	55.8 Fe	58.9 Co	58.7 Ni	63.5 Cu	65.4 Zn	69.7 Ga	72.6 Ge	74.9 As	79.0 Se	79.9 Br	83.8 Kr
5	85.5 Rb	87.6 Sr	88.9 Y	91.2 Zr	92.9 Nb	95.9 Mo	98.9 Tc	101 Ru	103 Rh	106 Pd	108 Ag	112 Cd	115 In	119 Sn	122 Sb	128 Te	127 I	131 Xe
6	133 Cs	137 Ba	139 La ►	179 Hf	181 Ta	184 W	186 Re	190 Os	192 Ir	195 Pt	197 Au	201 Hg	204 Tl	207 Pb	209 Bi	(210) Po	(210) At	(222) Rn
7	(223) Fr	(226) Ra	(227) Ac ►►															

f Block

►Lanthanoid elements	140 Ce	141 Pr	144 Nd	(147) Pm	150 Sm	(153) Eu	157 Gd	159 Tb	163 Dy	165 Ho	167 Er	169 Tm	173 Yb	175 Lu
►►Actinoid elements	232 Th	(231) Pa	238 U	(237) Np	(242) Pu	(243) Am	(247) Cm	(245) Bk	(251) Cf	(254) Es	(253) Fm	(256) Md	(254) No	(257) Lr

THE PERIODIC TABLE – KEY

ATOMIC NUMBER – SYMBOL – NAME

1 H - Hydrogen	38 Sr - Strontium	75 Re - Rhenium
2 He - Helium	39 Y - Yttrium	76 Os - Osmium
3 Li - Lithium	40 Zr - Zirconium	77 Ir - Iridium
4 Be - Beryllium	41 Nb - Niobium	78 Pt - Platinum
5 B - Boron	42 Mo - Molybdenum	79 Au - Gold
6 C - Carbon	43 Tc - Technetium	80 Hg - Mercury
7 N - Nitrogen	44 Ru - Ruthenium	81 Tl - Thallium
8 O - Oxygen	45 Rh - Rhodium	82 Pb - Lead
9 F - Fluorine	46 Pd - Palladium	83 Bi - Bismuth
10 Ne - Neon	47 Ag - Silver	84 Po - Polonium
11 Na - Sodium	48 Cd - Cadmium	85 At - Astatine
12 Mg - Magnesium	49 In - Indium	86 Rn - Radon
13 Al - Aluminium	50 Sn - Tin	87 Fr - Francium
14 Si - Silicon	51 Sb - Antimony	88 Ra - Radium
15 P - Phosphorus	52 Te - Tellurium	89 Ac - Actinium
16 S - Sulfur	53 I - Iodine	90 Th - Thorium
17 Cl - Chlorine	54 Xe - Xenon	91 Pa - Protactinium
18 Ar - Argon	55 Cs - Caesium	92 U - Uranium
19 K - Potassium	56 Ba - Barium	93 Np - Neptunium
20 Ca - Calcium	57 La - Lanthanum	94 Pu - Plutonium
21 Sc - Scandium	58 Ce - Cerium	95 Am - Americium
22 Ti - Titanium	59 Pr - Praseodymium	96 Cm - Curium
23 V - Vanadium	60 Nd - Neodymium	97 Bk - Berkelium
24 Cr - Chromium	61 Pm - Promethium	98 Cf - Californium
25 Mn - Manganese	62 Sm - Samarium	99 Es - Einsteinium
26 Fe - Iron	63 Eu - Europium	100 Fm - Fermium
27 Co - Cobalt	64 Gd - Gadolinium	101 Md - Mendelevium
28 Ni - Nickel	65 Tb - Terbium	102 No - Nobelium
29 Cu - Copper	66 Dy - Dysprosium	103 Lr - Lawrencium
30 Zn - Zinc	67 Ho - Holmium	
31 Ga - Gallium	68 Er - Erbium	
32 Ge - Germanium	69 Tm - Thulium	
33 As - Arsenic	70 Yb - Ytterbium	
34 Se - Selenium	71 Lu - Lutetium	
35 Br - Bromine	72 Hf - Hafnium	
36 Kr - Krypton	73 Ta - Tantalum	
37 Rb - Rubidium	74 W - Tungsten	