Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

Z22-A410U30-1

A410U30-1

Part of WJEC

THURSDAY, 23 JUNE 2022 – MORNING

CHEMISTRY – A level component 3

Chemistry in Practice

1 hour 15 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**14**	
2.	**15**	
3.	**11**	
4.	**13**	
5.	**7**	
Total	**60**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid. You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 60.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q.4**(b)(i)

Answer **all** questions.

1. A student was given four sets of compounds as shown below. He was asked to carry out a **chemical** test on each set of compounds that would allow him to distinguish between the compounds within each set.

For each set of compounds:

- Describe **one** chemical test the student could use. You may use the same reagents for more than one set.
- Give the **relevant observations** that would allow the student to distinguish between the compounds.
- Give an equation for **one** reaction that gives an observable change. State symbols are not required. [14]

Set **1**	
Solutions of	**A** barium nitrate **B** aluminium nitrate **C** magnesium nitrate
Chemical test	
Observations	
Equation	

Set **2**	
Solutions of	**D** phenol **E** ethanol **F** cyclohexene
Chemical test	
Observations	
Equation	

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Set **3**	
Solutions of	**G** chlorobenzene, C_6H_5Cl **H** (chloromethyl)benzene, $C_6H_5CH_2Cl$
Chemical test	
Observations	
Equation	

Set **4**	
Solutions of	**I** methyl ethanoate, CH_3COOCH_3 **J** ethanamide, CH_3CONH_2
Chemical test	
Observations	
Equation	

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03

14

Turn over.

2. The percentage purity of a sample of powdered magnesium hydroxide was determined by a back titration as follows.

Step	Method
1	2.762 g of a sample of powdered magnesium hydroxide was transferred into a 250 cm^3 beaker, and approximately 200 cm^3 of 0.460 $mol\,dm^{-3}$ hydrochloric acid added. The solution was warmed gently and stirred until the powder had all reacted.
2	This solution was transferred quantitatively into a 250 cm^3 volumetric flask and **made up to the mark with more of the same hydrochloric acid**. The flask was shaken well to ensure the solution was homogeneous. The solution was labelled as solution **W**.
3	A burette was prepared by rinsing twice with an appropriate solution before filling with 0.148 $mol\,dm^{-3}$ aqueous sodium hydroxide. The initial burette reading was taken.
4	25.0 cm^3 of solution **W** was transferred into a conical flask and 3–4 drops of phenolphthalein indicator added. The excess hydrochloric acid present was titrated with the sodium hydroxide until the solution turned a permanent pink colour. The volume of sodium hydroxide used was recorded.
5	The titration was repeated until concordant volumes of sodium hydroxide were obtained.

(a) Give the equation for the reaction of magnesium hydroxide with hydrochloric acid (step 1). [1]

....

(b) (i) Describe how the solution was transferred quantitatively into the volumetric flask (step 2). [1]

....

....

....

(ii) State why the solution is transferred in this way. [1]

....

....

(c) (i) Identify the appropriate solution with which to rinse the burette (step 3). [1]

....

(ii) Complete the results table below and use the concordant results to calculate the mean titre. [3]

Volume of NaOH(aq)	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Initial burette reading / cm^3	2.90	0.55	....	21.90	0.90
Final burette reading / cm^3	25.95	....	28.00	43.85	....
Titre / cm^3	....	22.70	21.85	....	21.90

Mean titre = ... cm^3

(d) (i) Calculate the number of moles of excess hydrochloric acid in 250 cm^3 of solution **W**. [2]

Number of moles of excess HCl = ... mol

(ii) Calculate the number of moles of hydrochloric acid that reacted with the powdered magnesium hydroxide. [2]

Number of moles of HCl that reacted = ... mol

(iii) Calculate the percentage purity of the sample of powdered magnesium hydroxide. [2]

Percentage purity = ... %

(e) The actual percentage purity is 80.3%.

Suggest the name of a contaminant that would prevent this experimental analysis from giving an accurate percentage purity. Explain your answer. [2]

....

....

15

3. The standard enthalpy change for the thermal decomposition of potassium hydrogencarbonate is represented by the following equation.

$$2KHCO_3(s) \longrightarrow K_2CO_3(s) + CO_2(g) + H_2O(g) \qquad \Delta H_1$$

It is not possible to measure the enthalpy change for this reaction directly. However, it is possible to measure accurately the enthalpy changes for the following two reactions in a school laboratory.

$$KHCO_3(s) + HCl(aq) \longrightarrow KCl(aq) + CO_2(g) + H_2O(l) \qquad \Delta H_2$$

$$K_2CO_3(s) + 2HCl(aq) \longrightarrow 2KCl(aq) + CO_2(g) + H_2O(l) \qquad \Delta H_3$$

These enthalpy values can then be used to calculate ΔH_1 using Hess's Law.

Part 1: <u>Enthalpy change of reaction of potassium carbonate (ΔH_3)</u>

In an experiment to determine ΔH_3, a student used 30.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid and 2.29 g of powdered anhydrous potassium carbonate.

(a) Outline a method to determine the temperature change during the reaction. [2]

....

....

....

....

....

(b) If the student calculated the enthalpy change ΔH_3 to be –43.2 kJ mol^{-1}, calculate the change in temperature. You can assume that the acid is in excess. [2]

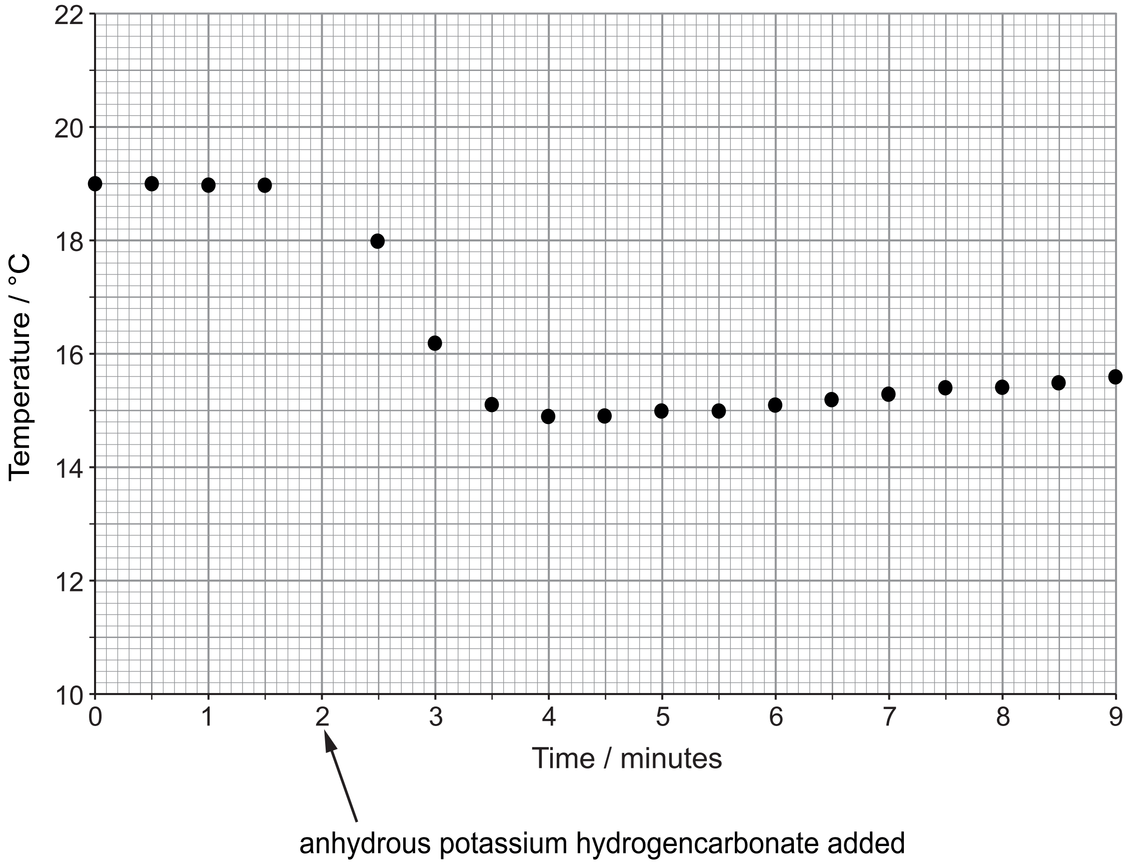
Change in temperature = ... °C

Turn over.

Part 2: Enthalpy change of reaction of potassium hydrogencarbonate (ΔH_2)

A similar experiment was used to determine ΔH_2, using 30.0 cm^3 of hydrochloric acid (an excess) and 4.03 g of anhydrous potassium hydrogencarbonate.

The resulting temperature/time plot is given below.



(c) Determine the maximum temperature change by drawing appropriate lines to complete the graph. [2]

ΔT = ... °C

(d) Calculate the molar enthalpy change of reaction, ΔH_2. [2]

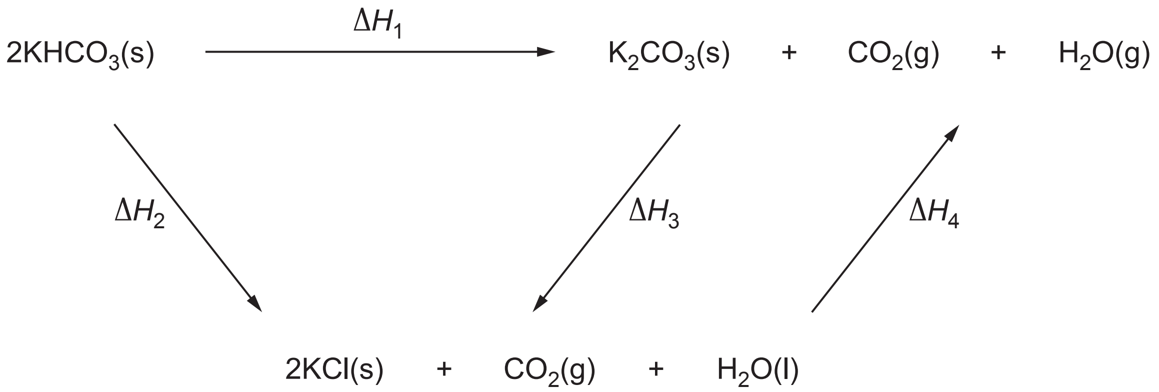
ΔH_2 = ... $kJ\,mol^{-1}$

Part 3: Enthalpy change of thermal decomposition of potassium hydrogencarbonate (ΔH_1)

(e) The enthalpy of vaporisation of water, ΔH_4, is 40.8 kJ mol^{-1}.

$$H_2O(l) \longrightarrow H_2O(g) \qquad \Delta H_4$$

Use the Hess's cycle shown below, and the values of ΔH_2, ΔH_3 and ΔH_4, to calculate the value of the standard enthalpy change of thermal decomposition of potassium hydrogencarbonate, ΔH_1. [2]



ΔH_1 = ... kJ mol^{-1}

(f) Suggest **one** reason why the enthalpy change for this reaction cannot be determined directly by calorimetry. [1]

....

....

11

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4. (a) The indicator thymol blue, which can be represented by the formula H Ind, is a weak acid.

It dissociates in solution and has a pK_a value of 8.9.

$$\underset{\text{yellow}}{\text{H Ind(aq)}} \rightleftharpoons \text{H}^+\text{(aq)} + \underset{\text{blue}}{\text{Ind}^-\text{(aq)}}$$

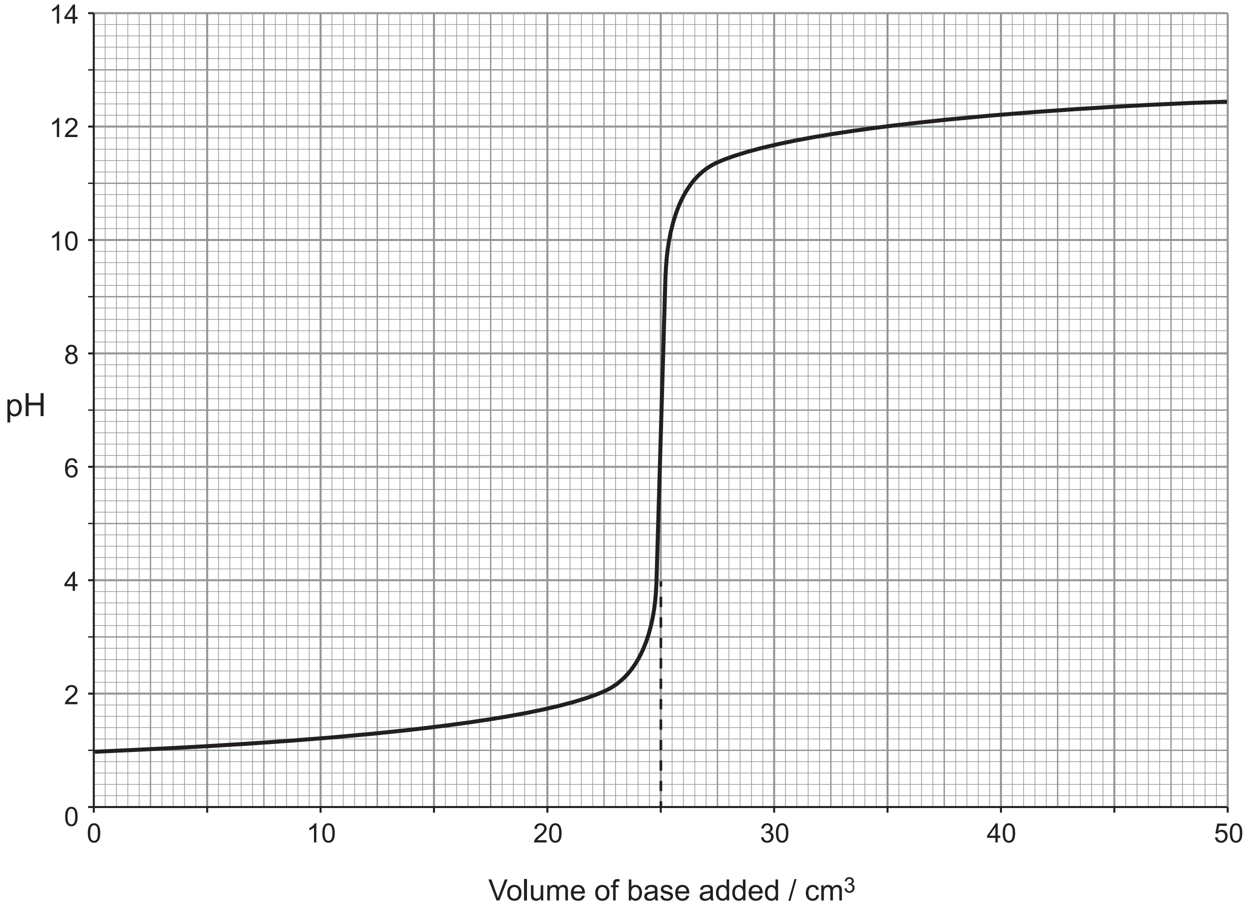
In an acid-base titration sodium hydroxide is added from a burette using thymol blue as an indicator. State the colour change that will occur, giving a reason for your answer. [2]

....

....

....

(b) (i) The following curve shows how the pH changes during the titration of a $0.10\,mol\,dm^{-3}$ solution of a strong acid against a $0.10\,mol\,dm^{-3}$ solution of a strong base.



Draw the titration curve obtained when $50.0\,cm^3$ of a $0.10\,mol\,dm^{-3}$ solution of a strong base is added gradually to $25.0\,cm^3$ of a $0.10\,mol\,dm^{-3}$ solution of a weak acid.

The weak acid has a K_a value of $1.80 \times 10^{-5}\,mol\,dm^{-3}$ at 298 K.

Give the pH values at key points during the titration and explain their significance.

[6 QER]

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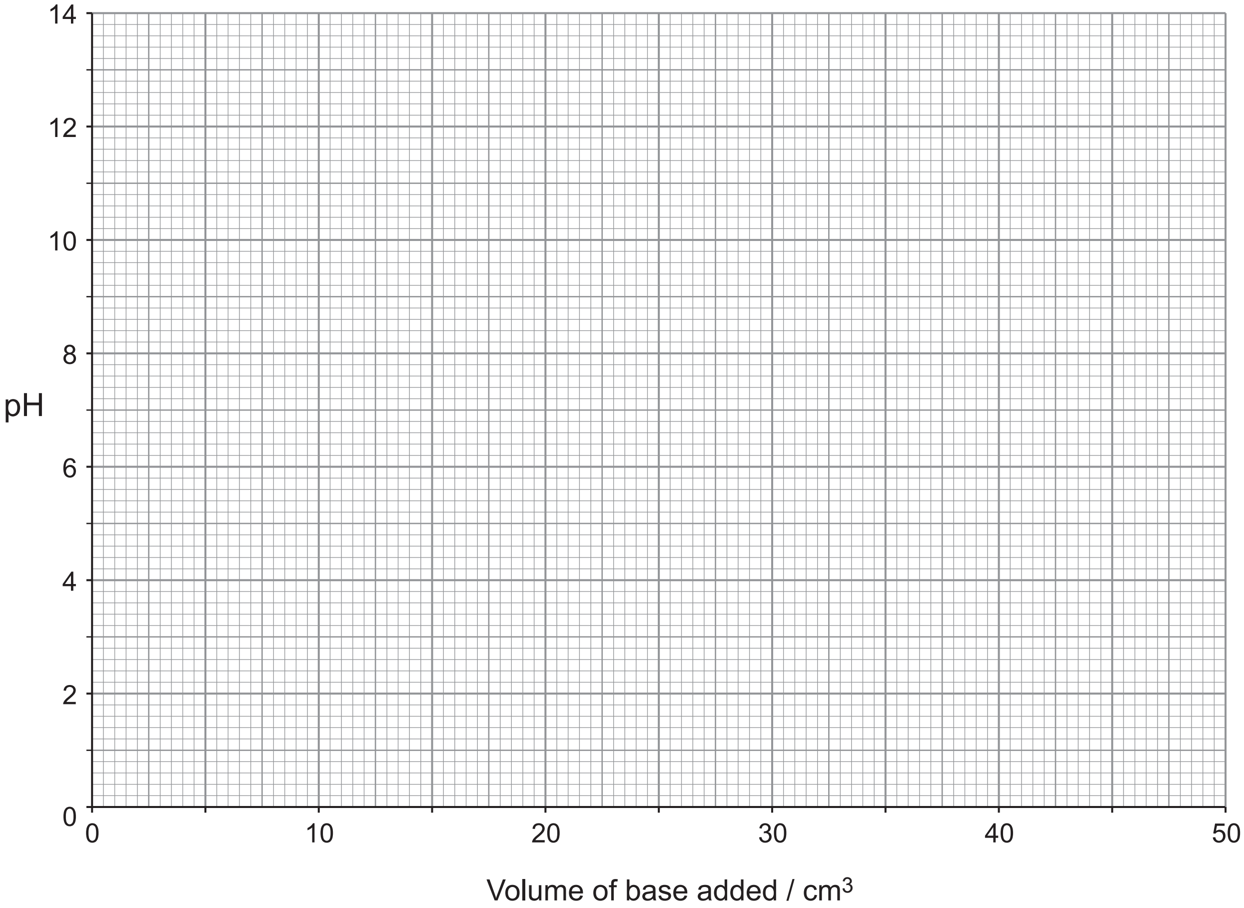

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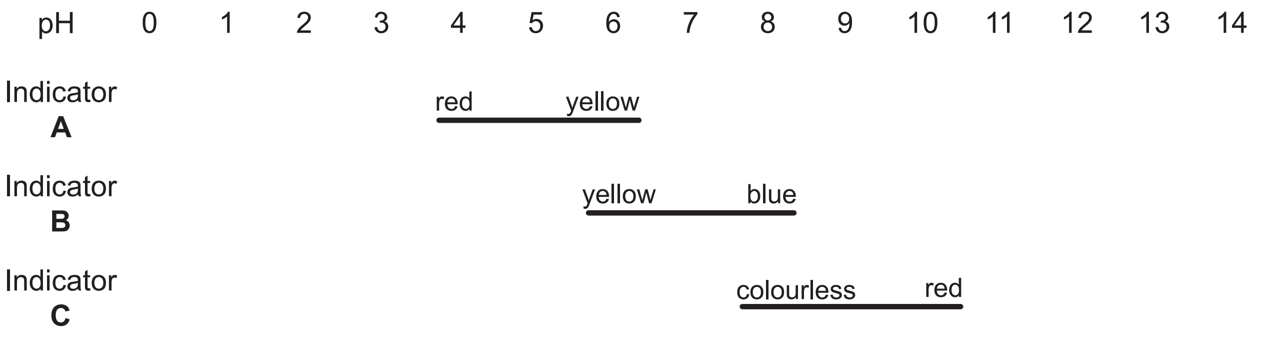
(ii) From the table below, suggest an appropriate indicator to use in this weak acid/strong base titration. Explain your answer. [1]



Examiner only

(c) An aqueous buffer was made by mixing 250 cm^3 of 0.262 mol dm^{-3} sodium propanoate and 500 cm^3 of 0.150 mol dm^{-3} propanoic acid at 298 K.

(K_a for propanoic acid = 1.34×10^{-5} mol dm^{-3} at 298 K)

(i) State the function of the sodium propanoate in the buffer solution. [1]

....

....

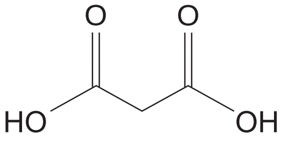
(ii) Calculate the pH of the buffer solution at 298 K. [3]

pH = ...

13

Turn over.

5. Malonic acid was first obtained in 1858 by the oxidation of malic acid, which is found in unripe apples.



malonic acid

(a) Give the systematic name of malonic acid. [1]

....

(b) Both malonic acid and compound **X** have the same molecular formula. Some of the properties of compound **X** are given below.

- Compound **X** does **not** show optical or geometric isomerism.
- The simplified ^{1}H NMR spectrum of compound **X** shows three separate peaks in the area ratio 1 : 1 : 2.
- A solution, containing 0.704 g of compound **X**, on reaction with excess sodium carbonate, gives 83.0 cm^3 of a colourless gas at 25°C and 1 atm pressure.
- Compound **X** does **not** react with 2,4-DNPH.
- Compound **X** decolourises aqueous bromine to form compound **Y** which has a chiral carbon.

Use **all** the information to identify and give the structures of compound **X** and compound **Y**. Show the chiral carbon in compound **Y**. [6]

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END OF PAPER

7

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

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GCE A LEVEL

A410U30-1A

Z22-A410U30-1A

THURSDAY, 23 JUNE 2022 – MORNING

CHEMISTRY – A level component 3
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
$1\ \text{atm} = 1.01 \times 10^5\ \text{Pa}$

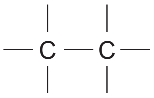
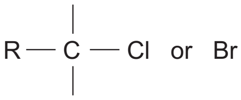
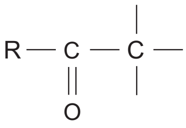
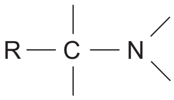
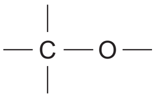
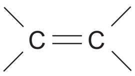
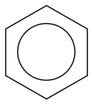
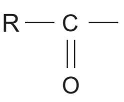
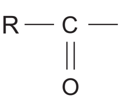
Multiple	Prefix	Symbol
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

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

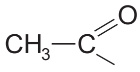
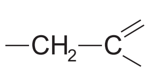
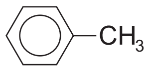
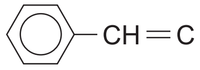
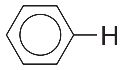
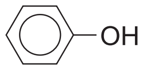
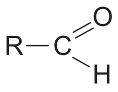
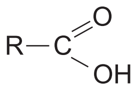
Infrared absorption values

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
$R-C\equiv N$	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

Group

s block

d block

p block

Key

A_r relative atomic mass
Symbol
Name
Z atomic number

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
6	133 Cs Caesium 55	137 Ba Barium 56	139 La ▸ Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 89															

f block

▸ Lanthanoid elements	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
▸▸ Actinoid elements	232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103