Oxford Cambridge and RSA

A Level Chemistry B (Salters)

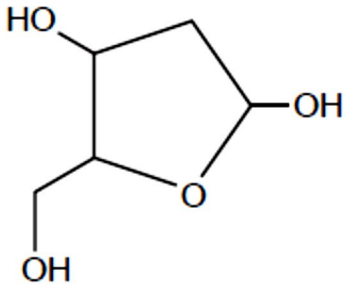
H433/02 Scientific literacy in chemistry

Question Set 3

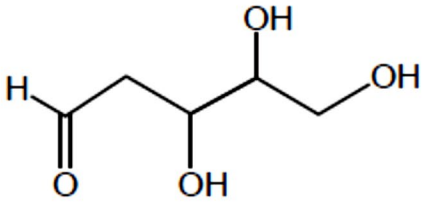
1 Deoxyribose, $C_5H_{10}O_4$, has a vital role in our biochemistry as a component of DNA.

Deoxyribose exists in solution as several forms, two of which are shown below.

(a) (i)



ring form



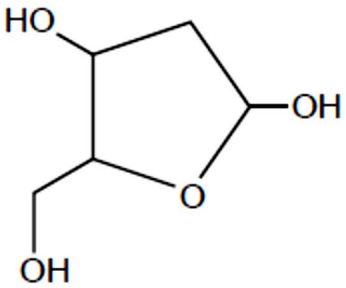
linear form

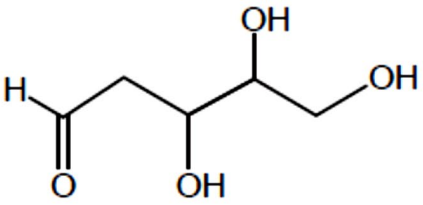
Circle **all** the chiral centres on **both** structures above. **[1]**

(ii) Name the functional group that is present in the linear form only. **[1]**

(iii) Describe a laboratory test for the functional group identified in **(a)(ii)**. **[2]**

(iv) Circle a primary alcohol group on each structure below, giving a reason for your choice.





Reason .....

.....

.....

[2]

(v) Explain why the reaction in which the linear form changes to the ring form is **not** condensation **[1]**

(vi) Complete the equation that shows the reaction when the linear form changes to the ringform.

–CHO + HO– ⟶

[1]

(b) In DNA, deoxyribose is always present as the ring form.
The primary alcohol group in the ring form of deoxyribose and the alcohol group on the adjacent carbon condense with phosphate groups.
A sugar-phosphate backbone is formed.

Draw a section of the sugar-phosphate backbone.

Show one deoxyribose and two phosphate groups. **[2]**

(c) **(i)** The structure of a fragment of DNA is sometimes represented by a sequence of letters, e.g. GCA. The letters stand for guanine, cytosine and adenine.

What single term describes guanine, adenine and cytosine?
How and where do they attach to the sugar-phosphate backbone?

Term ……

……

……

…… **[2]**

(ii) Give the DNA sequence that would produce the CUG sequence in RNA. **[1]**

(iii) The sequence given in **(c)(ii)** codes for an amino acid in a protein chain.

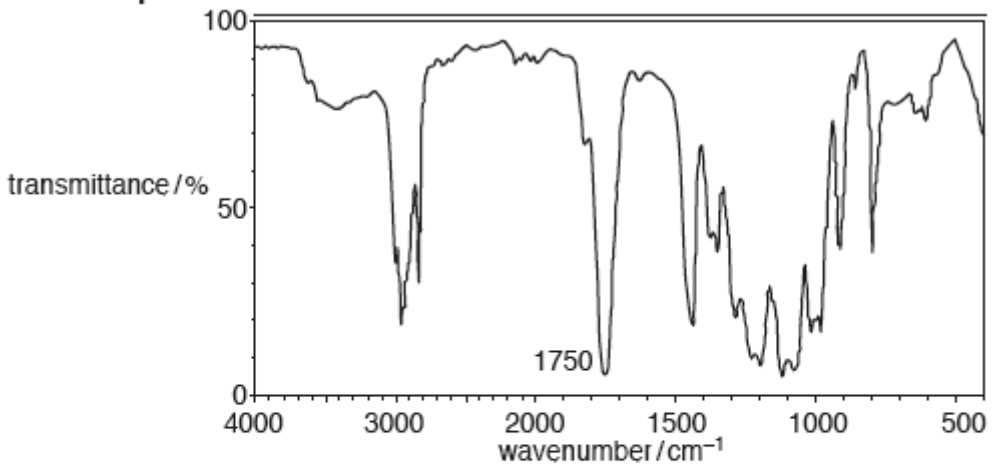
Name the amino acid. Use the *Data Sheet* to help you. **[1]**

(iv) Explain how a sequence in DNA codes for an amino acid. **[2]**

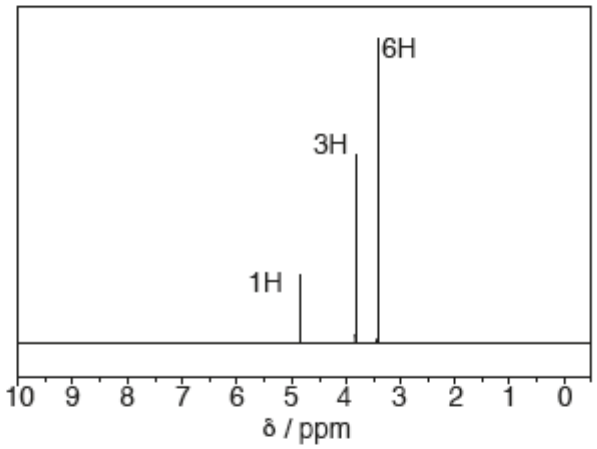
(d)* Compound **B** is a structural isomer of deoxyribose with the molecular formula $C_5H_{10}O_4$.

The infrared, ^1H and ^{13}C NMR spectra of compound **B** are shown below.

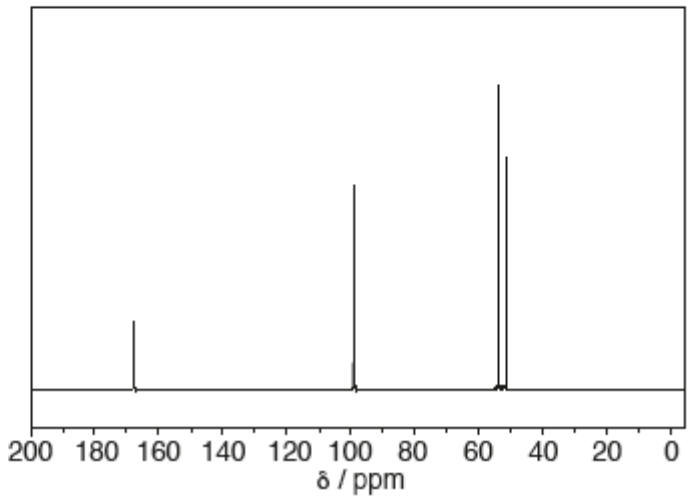
Infrared spectrum



^1H NMR spectrum



^{13}C NMR spectrum



Work out the structure of compound **B**.

Give evidence from **each** spectrum and show how it relates to the structure you have given. **[6]**

Total Marks for Question Set 3: 22

Resource Materials

Question Set No: 3

Data Sheet for Chemistry B

General Information

Molar gas volume = $24.0\,dm^3\,mol^{-1}$ at RTP

Avogadro constant, $N_A = 6.02 \times 10^{23}\,mol^{-1}$

Specific heat capacity of water, $c = 4.18\,J\,g^{-1}\,K^{-1}$

Planck constant, $h = 6.63 \times 10^{-34}\,J\,Hz^{-1}$

Speed of light in a vacuum, $c = 3.00 \times 10^{8}\,m\,s^{-1}$

Ionic product of water, $K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$ at 298 K

1 tonne = 10^6 g

Arrhenius equation: $k = Ae^{-E_a/RT}$ or $\ln k = -E_a/RT + \ln A$

Gas constant, $R = 8.314\,J\,mol^{-1}\,K^{-1}$

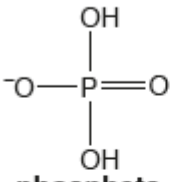
Triplet base codes (codons) for some amino acids used in mRNA

Glycine	GGU
Alanine	GCC
Leucine	CUG
Serine	UCG
Aspartic acid	GAU
Glutamine	CAA
Valine	GUC

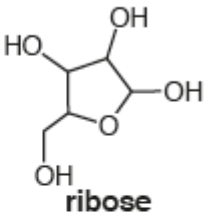
Characteristic infrared absorptions in organic molecules

Bond	Location	Wavenumber/cm^{-1}
C–H	Alkanes	2850–2950
	Alkenes, arenes	3000–3100
C–C	Alkanes	750–1100
C=C	Alkenes	1620–1680
aromatic C=C	Arenes	Several peaks in range 1450–1650 (variable)
C=O	Aldehydes	1720–1740
	Ketones	1705–1725
	Carboxylic acids	1700–1725
	Esters	1735–1750
	Amides	1630–1700
	Acyl chlorides and acid anhydrides	1750–1820
C–O	Alcohols, ethers, esters and carboxylic acids	1000–1300
C≡N	Nitriles	2220–2260
C–X	Fluoroalkanes	1000–1350
	Chloroalkanes	600–800
	Bromoalkanes	500–600
O–H	Alcohols, phenols	3200–3600 (broad)
	Carboxylic acids	2500–3300 (broad)
N—H	Primary amines	3300–3500
	Amides	*ca.* 3500

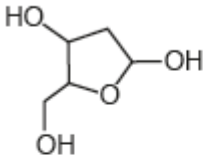
Monomers of DNA and RNA



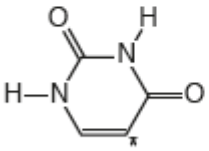
phosphate



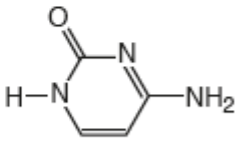
ribose



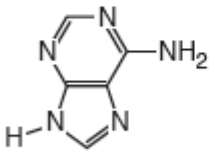
deoxyribose



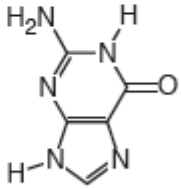
uracil



cytosine



adenine



guanine

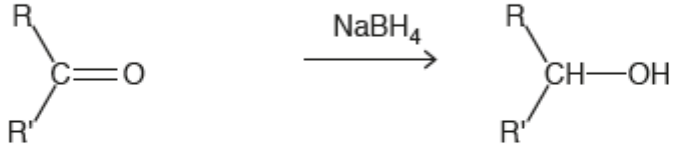
(thymine has a CH_3 at position *)

Some useful organic reactions

1 $R\text{–}Br + CN^- \longrightarrow R\text{–}CN + Br^-$

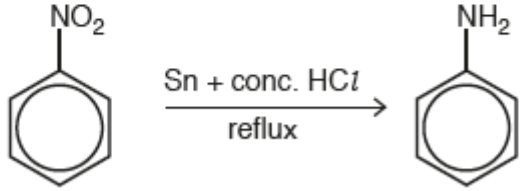
2 $R\text{–}CN \xrightarrow[\text{reflux}]{H^+ (aq)} R\text{–}COOH$

3

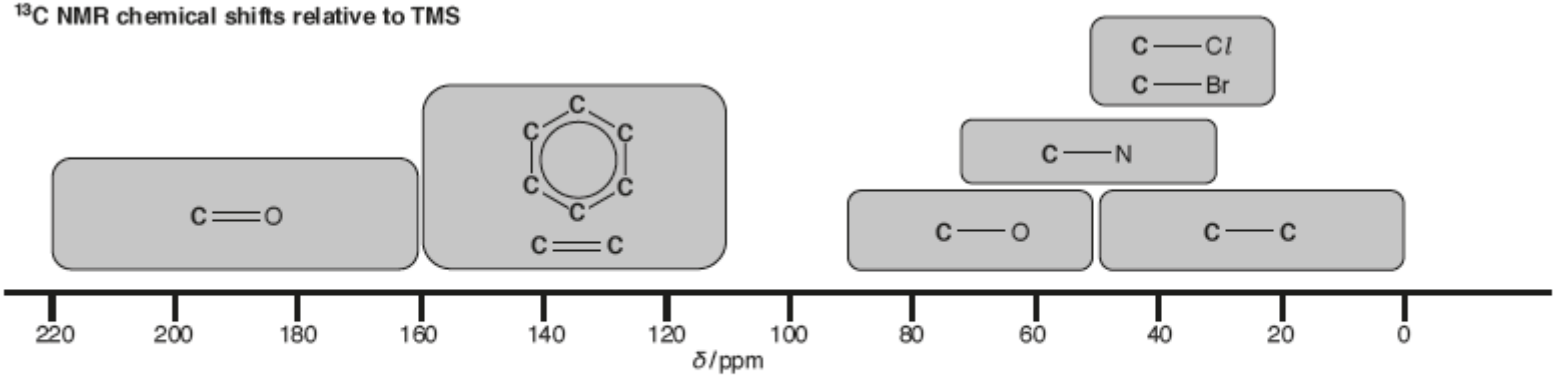


4 $R\text{–}COOH + SOCl_2 \longrightarrow R\text{–}COCl + SO_2 + HCl$

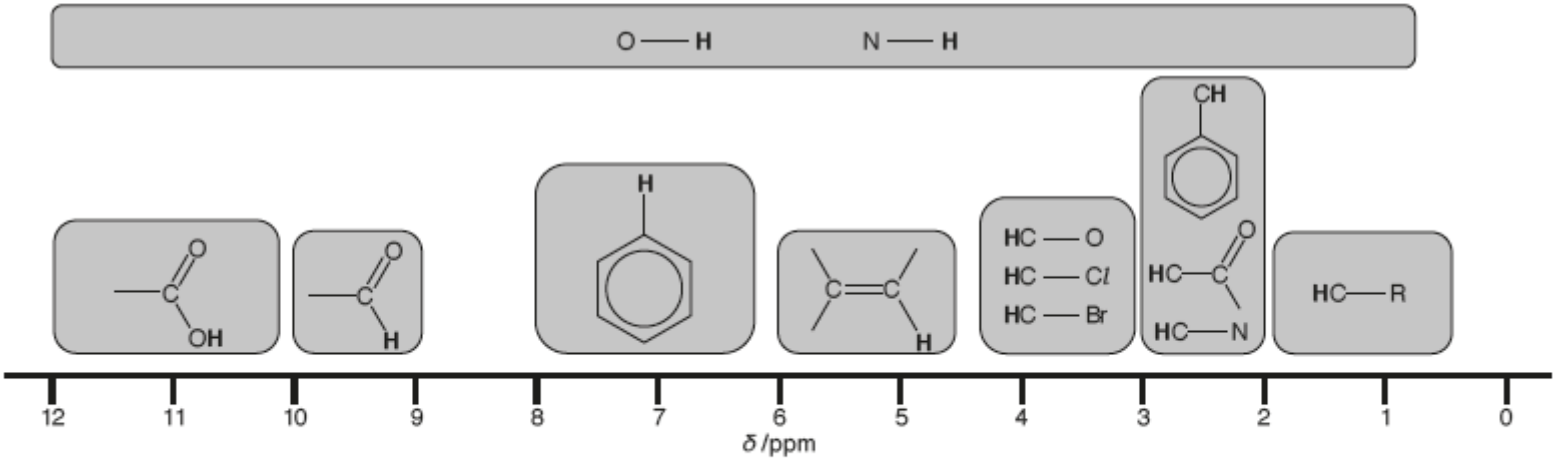
5



^{13}C NMR chemical shifts relative to TMS



^{1}H NMR chemical shifts relative to TMS



Chemical shifts are variable and can vary depending on the solvent, concentration and substituents. As a result, shifts may be outside the ranges indicated above.

O**H** and N**H** chemical shifts are very variable and are often broad. Signals are not usually seen as split peaks.

Note that C**H** bonded to 'shifting groups' on either side, e.g. O–C**H**$_2$–C=O, may be shifted more than indicated above.

The Periodic Table of the Elements

(1)	(2)											(3)	(4)	(5)	(6)	(7)	(0)
1																	18
1 H hydrogen 1.0	2		Key atomic number Symbol name relative atomic mass									13	14	15	16	17	2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89–103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium		114 Fl flerovium		116 Lv livermorium		

57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium 144.9	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.2	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.0	71 Lu lutetium 175.0
89 Ac actinium	90 Th thorium 232.0	91 Pa protactinium	92 U uranium 238.1	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium