Letts

A-level

Chemistry

Practice paper for AQA

Paper 3

Time allowed: 2 hours

Materials

For this paper you must have:

- the Data Booklet, see pages 91–93
- a ruler
- a calculator.

Instructions

- Answer **all** questions.
- Show **all** your working.

Information

- The maximum mark for this paper is 90.

Name: .....

Section A

Answer **all** questions in this section.

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0 1 This question is about making a standard solution and titrating it.

A student attempts to make 250 cm^3 of a 0.10 mol dm^{-3} solution of sodium hydrogensulfate, ($NaHSO_4$).

0 1 · 1 Calculate the mass of sodium hydrogensulfate the student needs for the solution.

[2 marks]

.....

.....

0 1 · 2 The student has access to a digital top-pan balance that reads to 0.01 g. She places a weighing boat on the balance and adds the sodium hydrogensulfate until she has the correct mass. The student transfers the sodium hydrogensulfate into a glass beaker and then re-weighs the weighing boat.

What is the purpose of re-weighing the weighing boat after the sodium hydrogensulfate has been transferred into the beaker?

[1 mark]

.....

0 1 · 3 What is the percentage error in the measurement of the mass of the sodium hydrogensulfate?

[1 mark]

.....

0 1 · 4 The student then adds distilled water to the beaker and stirs the solution with a glass rod until all of the solid is dissolved. She then pours the solution into a 250 cm^3 volumetric flask.

What should the student do to ensure that no sodium hydrogensulfate is lost at this stage?

[1 mark]

.....

.....

0 1 · 5 The student then adds more distilled water to the volumetric flask, adding the last few drops with a dropping pipette, to ensure that the total volume of the solution is 250 cm^3.

How should the student accurately check the total volume of the solution in the flask?

[2 marks]

0 1 · 6 Write an ionic equation for the acid-base reaction between hydrogensulfate ions and hydroxide ions.

[1 mark]

0 1 · 7 To accurately test the concentration of the sodium hydrogensulfate solution she had made, the student set up a titration experiment, using a standard solution of sodium hydroxide. A 25.0 cm^3 sample of her solution took 24.60 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution to neutralise it. Calculate the actual concentration of her sodium hydrogensulfate solution.

[2 marks]

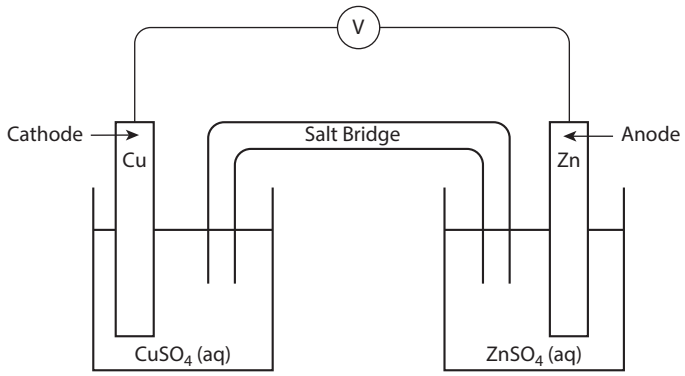
0 1 · 8 The student believes that her results suggest that the sodium hydrogensulfate she used was not pure. If this is taken to be the **only** cause of the concentration of her solution not being as she expected, calculate the percentage purity of the sodium hydrogensulfate she used.

[2 marks]

0 2 This question is about electrochemical cells.

Figure 1 shows how a student combined a zinc half-cell and a copper half-cell to measure the EMF.

Figure 1



0 2 · 1 Write equations for the equilibria in each half-cell.

[2 marks]

Zinc half-cell

.....

Copper half-cell

.....

0 2 · 2 Explain why the zinc is the negative electrode (anode) in this cell.

[1 mark]

.....

.....

0 2 · 3 Use the following data to work out the EMF of the cell under standard conditions.

E^{θ} Cu = +0.34 V

E^{θ} Zn = –0.76 V

[1 mark]

.....

0 2 · 4 Predict and explain what would happen to the cell EMF if the student were to add distilled water to the zinc half-cell.

[4 marks]

Prediction

Explanation

0 2 · 5 Write an equation for the reaction that would happen if the cell were to be short-circuited, allowing current to flow from one half of the cell to the other.

[1 mark]

0 2 · 6 Explain, in terms of electron transfer, why this is a 'redox' reaction.

[3 marks]

0 3 This question is about calorimetry.

A student measured 25.0 cm^3 of a 0.50 mol dm^{-3} solution of copper sulfate into a glass beaker. He measured the temperature of the solution, using a thermometer. He then added 0.50 g of powdered magnesium and measured the maximum temperature reached by the reaction mixture as seen in **Table 1**.

Table 1

Initial temperature of solution (°C)	21.0
Maximum temperature of solution (°C)	26.5

0 3 · 1 What piece of apparatus should the student choose to accurately measure the volume of copper sulfate solution?

[1 mark]

.....

0 3 · 2 Write a balanced equation for the reaction taking place in the beaker.

[1 mark]

.....

0 3 · 3 Calculate the number of moles of magnesium that have reacted in this experiment, giving your answer to three significant figures.

[2 marks]

.....

.....

0 3 · 4 Use the student's original data to calculate the enthalpy change for the reaction between magnesium and copper sulfate solution.

[2 marks]

.....

.....

.....

0 3 · 5 Identify the main source of error in the experiment and suggest how it might be overcome.

[2 marks]

Source of error

.....

Suggested improvement

.....

.....

.....

0 3 · 6 Describe and explain the effect on the measured temperature change had the student used 25.0 cm^3 of 1.0 mol dm^{-3} copper sulfate solution with the same mass of magnesium.

[2 marks]

Effect

.....

Explanation

.....

.....

0 3 · 7 Describe and explain the effect on the temperature change had the student added 1.0 g of magnesium powder to the same volume of 0.5 mol dm^{-3} copper sulfate solution.

[2 marks]

Effect

.....

Explanation

.....

.....

0 4 This question is about preparation of an aldehyde.

Ethanal may be prepared in the laboratory by oxidising ethanol. A suitable oxidising agent is made by dissolving 10.0 g of potassium dichromate in 100 cm^3 of 1.0 mol dm^{-3} sulfuric acid.

A student combined 2.0 cm^3 of ethanol with 12.0 cm^3 of the acidified dichromate solution in a boiling tube. She fitted a delivery tube, leading to a second boiling tube that was standing in a beaker of iced water. Gentle heating of the mixture produced around 5 cm^3 of a colourless distillate.

0 4 · 1 Write an equation to show the oxidation of ethanol to ethanal (you may use [O] to represent the oxidising agent).

[1 mark]

.....

0 4 · 2 One problem with the method described is that there is a risk that the reaction mixture might boil over into the collection tube.

Describe **two** ways that the student could reduce the risk of this happening.

[2 marks]

.....

.....

.....

.....

0 4 · 3 Explain why the collection tube should be standing in a beaker of iced water.

[2 marks]

.....

.....

.....

0 4 · 4 Describe **one** chemical test that the student could carry out to show that the distillate contained ethanal. Include the expected result.

[2 marks]

.....

.....

.....

0 4 · 5 One impurity that may be present in the distillate is ethanoic acid. Describe how this may have been produced in this preparation and outline how it may be separated from the ethanal.

[2 marks]

0 4 · 6 Oxidation of 4.6 g of ethanol produced 3.8 g of ethanal. Calculate the percentage yield.

[3 marks]

0 5 This question is about the techniques used in titration.

A student plans to titrate a solution of ethanoic acid with a standard solution of sodium hydroxide. Preliminary testing of the solution using phenolphthalein indicator suggests that the concentration of the sodium hydroxide solution should be 0.01 mol dm^{-3}. The student fills a burette with the sodium hydroxide solution and pipettes 25.0 cm^3 of the ethanoic acid solution into a clean conical flask. The student decides to use a digital pH meter to improve the accuracy of his pH measurements.

0 5 · 1 What should each of the following pieces of equipment be rinsed with, prior to use, in this experiment?

[3 marks]

Burette .....

Pipette .....

Conical flask .....

0 5 · 2 Explain why phenolphthalein, which has a pK_{in} of 9, is the correct indicator to use in the preliminary testing to determine the best concentration of sodium hydroxide solution to use.

[2 marks]

.....

.....

.....

0 5 · 3 What must the student do to determine the equivalence/end-point when using the digital pH meter?

[2 marks]

.....

.....

.....

0 5 · 4 Why might the pH of the titration mixture remain relatively constant when the volume of sodium hydroxide solution added was between 10.0 cm^3 and 15.0 cm^3?

[1 mark]

.....

0 5 · 5 The student decides, instead, to check the expected pH at the equivalence/end-point by making up a solution of sodium ethanoate and testing its pH in advance.

Assuming the concentration of the ethanoic acid to be approximately equal to that of the sodium hydroxide solution, what concentration of sodium ethanoate solution should the student prepare?

[2 marks]

0 5 · 6 Comment on the suitability, or otherwise, of the student's chosen method for establishing the concentration of the ethanoic acid solution, giving your reasons.

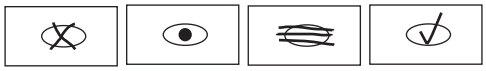
[2 marks]

Section B

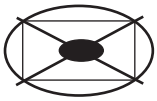
Answer **all** questions in this section.

Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD  WRONG METHODS 

If you want to change your answer, you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

0 6 When chlorine reacts with benzene, it acts as

[1 mark]

A an electrophile. ⬭

B a nucleophile. ⬭

C a reducing agent. ⬭

D a free radical. ⬭

0 7 Which of these is **not** a reason why potassium is a more reactive element than sodium?

[1 mark]

A Potassium's outer shell electron is further from the nucleus. ⬭

B Potassium has a more positively charged nucleus. ⬭

C Potassium has a lower first ionisation energy than sodium. ⬭

D In a potassium atom, the outer shell electron experiences more shielding. ⬭

0 8 5.00 kg of calcium carbonate produces 2.50 kg of calcium oxide by thermal decomposition. What volume of carbon dioxide would be produced (measured at 298 K and 101 kPa)?

[1 mark]

A 1200.0 dm^3 ⬭

B 600.0 dm^3 ⬭

C 714.2 dm^3 ⬭

D 1071.4 dm^3 ⬭

0 9 A pair of enantiomers will exhibit a difference in

[1 mark]

A melting point. ⬭

B rotation of plane-polarised light. ⬭

C reactivity. ⬭

D solubility. ⬭

1 0 Which electron arrangement belongs to a halogen?

[1 mark]

A $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ ⬭

B $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$ ⬭

C $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$ ⬭

D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$ ⬭

1 1 Which of these has the compounds arranged in order of increasing boiling point?

[1 mark]

A $CH_3CH_2CH_2CH_3$, $CH_3CH(OH)CH_3$, CH_3CH_2COOH, CH_3COCH_3 ⬭

B CH_3COCH_3, $CH_3CH(OH)CH_3$, CH_3CH_2COOH, $CH_3CH_2CH_2CH_3$ ⬭

C $CH_3CH_2CH_2CH_3$, CH_3COCH_3, $CH_3CH(OH)CH_3$, CH_3CH_2COOH ⬭

D CH_3CH_2COOH, $CH_3CH_2CH_2CH_3$, CH_3COCH_3, $CH_3CH(OH)CH_3$ ⬭

1 2 Which of these oxides would have the lowest pH?

[1 mark]

A Na_2O ⬭

B Al_2O_3 ⬭

C SO_2 ⬭

D SiO_2 ⬭

1 3 In the rate equation $r = k[A][B]^2$, if the rate units are mol dm^{-3} s^{-1}, what could the units for k be?

[1 mark]

A $mol^2\ dm^{-6}\ s^{-1}$ ⬭

B $mol^{-2}\ dm^6\ s^{-1}$ ⬭

C $mol^3\ dm^{-9}\ s^{-1}$ ⬭

D $mol^{-3}\ dm^9\ s^{-1}$ ⬭

1 4 If the forward reaction in an equilibrium is exothermic, which statement is true?

[1 mark]

A The equilibrium will be unaffected by changes in pressure. ⬭

B An increase in temperature decreases the proportion of products. ⬭

C An increase in temperature decreases the proportion of reactants. ⬭

D The rate of the forward reaction is unaffected by a change in temperature. ⬭

1 5 Which combination is most likely to produce an alkene from a halogenoalkane?

[1 mark]

A Concentrated potassium hydroxide in ethanol, high temperature ⬭

B Concentrated aqueous potassium hydroxide, low temperature ⬭

C Dilute potassium hydroxide in ethanol, low temperature ⬭

D Dilute aqueous potassium hydroxide, high temperature ⬭

1 6 Which of the following will give no reaction with a mixture of potassium dichromate and sulfuric acid?

[1 mark]

A Propanone ⬭

B Propan-1-ol ⬭

C Propan-2-ol ⬭

D Propanal ⬭

1 7 If a transition metal complex ion has a co-ordination number of 6, what is its most likely shape?

[1 mark]

A Trigonal bipyramidal ⬭

B Tetrahedral ⬭

C Octahedral ⬭

D Square planar ⬭

1 8 Which of the following decreases across the Period Na–Ar?

[1 mark]

A Nuclear charge ⬭

B First ionisation energy ⬭

C Ionic radius ⬭

D Atomic radius ⬭

1 9 0.5 moles of carbon dioxide would occupy what volume, in dm^3 , at 373 K and 101 kPa? ($R = 8.31\ J\ K^{-1}\ mol^{-1}$)

[1 mark]

A 30.6 ⬭

B 22.4 ⬭

C 15.3 ⬭

D 24.0 ⬭

2 0 An equilibrium mixture of the following:

$2NO_{2(g)} \rightleftharpoons O_{2(g)} + 2NO_{(g)}$

at 500 K and 1 atm, contains 0.96 mol of $NO_{2(g)}$, 0.04 mol of $NO_{(g)}$ and 0.02 mol of $O_{2(g)}$.

What is the value of K_p for this reaction, under these conditions?

[1 mark]

A 8.65×10^{-4} atm ⬭

B 3.39×10^{-5} atm ⬭

C 8.13×10^{-4} atm ⬭

D 8.13×10^{-4} atm ⬭

2 1 Which of these hydroxides is the least soluble in water?

[1 mark]

A $Mg(OH)_2$ ⬭

B NaOH ⬭

C KOH ⬭

D $Ca(OH)_2$ ⬭

2 2 Which of these equations represents the first electron affinity of chlorine?

[1 mark]

A $Cl_{2(g)} \rightarrow 2Cl^+_{(g)} + 2e^-$ ⬭

B $Cl_{(g)} + e^- \rightarrow Cl^-_{(g)}$ ⬭

C $Cl_{2(g)} + 2e^- \rightarrow 2Cl^-_{(g)}$ ⬭

D $Cl_{(g)} \rightarrow Cl^-_{(g)} + e^-$ ⬭

2 3 Which of these can act as a nucleophile?

[1 mark]

A Br_2 ⬭

B HBr ⬭

C Br• ⬭

D Br^- ⬭

2 4 What is the pH of a 1.50 mol dm^{-3} solution of ethanoic acid? ($K_a = 1.7 \times 10^{-5}$)

[1 mark]

A 2.30 ⬭

B 4.50 ⬭

C 5.05 ⬭

D 3.35 ⬭

2 5 Which combination results in a reaction that is spontaneous only at high temperatures?

[1 mark]

	ΔH^θ	ΔS^θ_{system}	
A	negative	positive	⬭
B	positive	positive	⬭
C	negative	negative	⬭
D	positive	negative	⬭

2 6 Element X has four isotopes: ^{82}X (12%), ^{83}X (12%), ^{84}X (50%), and ^{86}X (26%). What is the A_r of X?

[1 mark]

A 82.42 ⬭

B 84.16 ⬭

C 83.35 ⬭

D 85.20 ⬭

2 7 To calculate the activation energy for a reaction, an Arrhenius plot is used: this is a graph of

[1 mark]

A ln *k* against 1/T. ⬭

B *k* against ln 1/T. ⬭

C 1/T against *k*. ⬭

D T against 1/ln*k*. ⬭

2 8 On a thin-layer chromatogram, the solvent front is at 28.7 cm and the spot produced by an amino acid is at 13.9 cm. What is the R_f value of the amino-acid?

[1 mark]

A 2.06 ⬭

B 0.48 ⬭

C 0.20 ⬭

D 4.84 ⬭

2 9 If the sequence of numbers represent the first six ionisation energies of an element, which of the elements is in Group 5 of the Periodic Table?

[1 mark]

A 1251, 2300, 3820, 5160, 6540, 9360 ⬭

B 578, 1820, 2750, 11600, 14800, 18400 ⬭

C 1010, 1900, 2910, 4960, 6270, 21269 ⬭

D 738, 1450, 7730, 10500, 13600, 18000 ⬭

3 0 What would you expect to observe if a solution containing silver nitrate and nitric acid is added to a solution of barium chloride?

[1 mark]

A Effervescence ⬭

B A white precipitate of silver chloride ⬭

C A white precipitate of barium nitrate ⬭

D No evidence of a reaction ⬭

3 1 The atom economy of the blast-furnace reduction of iron(III) oxide, to produce iron

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$, is

[1 mark]

A 35%. ⬭

B 68%. ⬭

C 57%. ⬭

D 46%. ⬭

3 2 Which of the following molecules contains a chiral carbon atom?

[1 mark]

A Propan-1-ol ⬭

B Propan-1,2-diol ⬭

C Propan-1,3-diol ⬭

D Propan-1,2,3-triol ⬭

3 3 Nitration of 7.80 g of benzene produces 9.84 g of nitrobenzene. What is the percentage yield?

[1 mark]

A 100% ⬭

B 80% ⬭

C 60% ⬭

D 70% ⬭

3 4 Which of these species has a bond angle of 180°?

[1 mark]

A SO_2 ⬭

B CO_3^{2-} ⬭

C CO_2 ⬭

D NH_3 ⬭

3 5 When potassium manganate VII oxidises an iron II compound to an iron III compound, the change in the oxidation number of manganese is

[1 mark]

A from +7 to +3. ⬭

B from +7 to +6. ⬭

C from +7 to +5. ⬭

D from +7 to +2. ⬭

END OF QUESTIONS

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
																	(18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
(1)	(2)		**Key**									(13)	(14)	(15)	(16)	(17)	
6.9 **Li** lithium 3	9.0 **Be** beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									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
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(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	39.9 **Ar** argon 18
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
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	96.0 **Mo** molybdenum 42	[98] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La*** lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac†** actinium 89	[267] **Rf** rutherfordium 104	[268] **Db** dubnium 105	[271] **Sg** seaborgium 106	[272] **Bh** bohrium 107	[270] **Hs** hassium 108	[276] **Mt** meitnerium 109	[281] **Ds** darmstadtium 110	[280] **Rg** roentgenium 111	Elements with atomic numbers 112–116 have been reported but not fully authenticated						

* **58 – 71** Lanthanides	140.1 **Ce** cerium 58	140.9 **Pr** praseodymium 59	144.2 **Nd** neodymium 60	[145] **Pm** promethium 61	150.4 **Sm** samarium 62	152.0 **Eu** europium 63	157.3 **Gd** gadolinium 64	158.9 **Tb** terbium 65	162.5 **Dy** dysprosium 66	164.9 **Ho** holmium 67	167.3 **Er** erbium 68	168.9 **Tm** thulium 69	173.0 **Yb** ytterbium 70	175.0 **Lu** lutetium 71
† **90 – 103** Actinides	232.0 **Th** thorium 90	231.0 **Pa** protactinium 91	238.0 **U** uranium 92	[237] **Np** neptunium 93	[244] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[247] **Bk** berkelium 97	[251] **Cf** californium 98	[252] **Es** einsteinium 99	[257] **Fm** fermium 100	[258] **Md** mendelevium 101	[259] **No** nobelium 102	[262] **Lr** lawrencium 103

Chemistry Data Sheet

Table A

Infrared absorption data

Bond	Wavenumber/cm^{-1}
N — H (amines)	3300–3500
O — H (alcohols)	3230–3550
C — H	2850–3300
O — H (acids)	2500–3000
C ≡ N	2220–2660
C = O	1680–1750
C = C	1620–1680
C — O	1000–1300
C — C	750–1100

Table B

^{1}H NMR chemical shift data

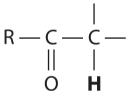
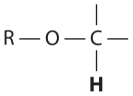
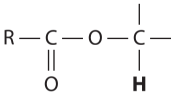
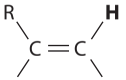
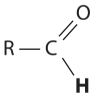
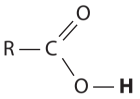
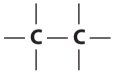
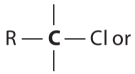
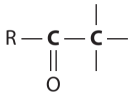
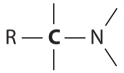
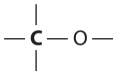
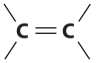
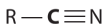
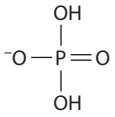
Type of proton	δ/ppm
ROH	0.5–5.0
RCH$_3$	0.7–1.2
RNH$_2$	1.0–4.5
R$_2$CH$_2$	1.2–1.4
R$_3$CH	1.4–1.6
	2.1–2.6
	3.1–3.9
RCH$_2$Cl or Br	3.1–4.2
	3.7–4.1
	4.5–6.0
	9.0–10.0
	10.0–12.0

Table C

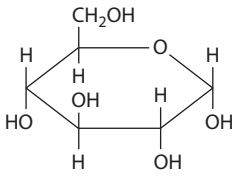
^{13}C NMR chemical shift data

Type of carbon		δ/ppm
		5–40
		10–70
		20–50
		25–60
	alcohols, ethers or esters	50–90
		90–150
		110–125
		110–160
	esters or acids	160–185
	aldehydes or ketones	190–220

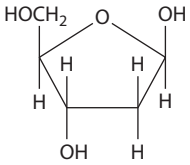
Phosphate and sugars



phosphate

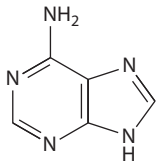


glucose

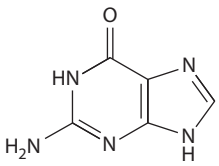


2-deoxyribose

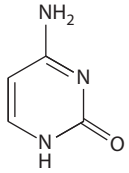
Bases



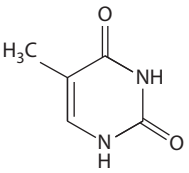
adenine



guanine

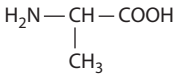


cytosine

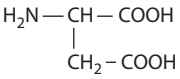


thymine

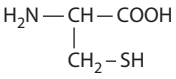
Amino acids



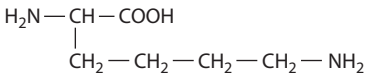
alanine



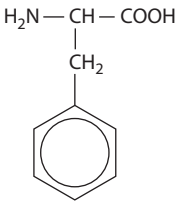
aspartic acid



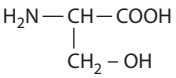
cysteine



lysine



phenylalanine



serine

Haem B