Chemistry

SAMPLE

Marking Scheme

This marking scheme has been prepared as a **guide only** to markers. This is not a set of model answers, or the exclusive answers to the questions, and there will frequently be alternative responses which will provide a valid answer. Markers are advised that, unless a question specifies that an answer be provided in a particular form, then an answer that is correct (factually or in practical terms) **must** be given the available marks.

If there is doubt as to the correctness of an answer, the relevant NCC Education materials should be the first authority.

Throughout the marking, please credit any valid alternative point.

Where markers award half marks in any part of a question, they should ensure that the total mark recorded for the question is rounded up to a whole mark.

Marks

Answer ALL questions

Question 1

a) Elements are the simplest chemical substances and are made up of atoms. Atoms contain three simple sub-atomic particles: protons, neutrons and electrons. The protons and neutrons are found in the nucleus and the electrons travel around the nucleus.

i) According to Quantum Mechanics, what is the name given to area of the atom where there is a high possibility of finding an electron? **1**
Orbital or shell

ii) The electrons in these areas have to obey the Pauli exclusion principle. What does this principle state? **1**
No electron in an orbital can have the same four principle quantum numbers.

b) The two main isotopes of carbon are ^{12}C and ^{13}C.

i) What is the definition of an isotope? **1**
Atoms of the same element which differ in mass number (or the number neutrons).

ii) Copy the table below and for each isotope give the number of protons, electrons and neutrons. **4**

Isotope	Number of protons	Number of neutrons	Number of electrons
^{12}C			6
^{13}C	6		

Isotope	Number of protons	Number of neutrons	Number of electrons
^{12}C	***6***	***6***	6
^{13}C	6	***7***	***6***

iii) Calculate the number of carbon atoms in 32g of carbon solid. **2**

1 mole ⟶ 6.02×10^{23} ***atoms***
12g ⟶ 6.02×10^{23} ***atoms (1 mark)***
32g ⟶ $\frac{32 \times 6.02 \times 10^{23}}{12}$

$=1.605 \times 10^{24}$ ***molecules (1 mark)***

c) The three main trends in the Periodic Table are atomic size (radii), ionisation energy and electronegativity.

i) Define the term “first ionisation energy”. **1**
Energy required to remove one mole of electrons from one mole of atoms in the gas state to form one mole of ions, in the gas state.

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Marks

ii) Write the equation for the 1st ionisation of one mole of lithium atoms in the gaseous state to form one mole of gaseous lithium ions. **2**

$Li_{(g)} \rightarrow Li^{+}_{(g)} + e^{-}$

iii) Describe and explain what happens to the size of an atom going across a period. **2**

Decreases across a period (1 mark). Positive charge on the nucleus increases (increase in protons) and no further electron shells are being added (1 mark).

d) Electronegativity values can be used to infer the type of bonding that might be present in a compound. Some electronegativity values can be seen in the table below.

Element	**Electronegativity (Pauling Scale)**
Li	1.0
Na	0.9
K	0.8
F	4.0
Cl	3.0
Br	2.8

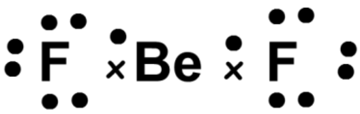
i) Use the table above to find out which compound will have bonds with the most ionic character. Work out an actual overall electronegativity value for the bond in this compound. **2**

KF (1 mark)
Gives the largest difference in electronegativity values 4.0-0.8=3.2 (1 mark)

ii) Intermolecular forces can be found in a number of covalent compounds. What is the name of the main intermolecular force found in water? **1**

Hydrogen bonding

iii) The electronic structure and shape of various covalent molecules, like beryllium fluoride, can be worked out using a number of theories. Draw a Lewis dot/cross diagram for beryllium fluoride and work out the shape of the molecule using the VSEPR theory. Show ALL of the outer electrons in the Lewis diagram. **3**



(1 mark)

<u>VSEPR</u>
Electrons on central atom available for bonding=2
Electron from bonded atoms=1x 2=2
Bonding electron pairs=2
Non-bonding electron pairs=0
(1 mark)
Shape =Linear (1 mark)

Total 20 Marks

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Marks

Question 2

a) Ammonia gas (NH_3) is produced by the Haber process. This involves a reversible reaction with hydrogen and nitrogen gases acting as the reactants. The production of ammonia is an exothermic process.

i) Write a balanced equation for the formation of ammonia. Include state symbols. **2**

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

Correct formulae (1 mark)
Balanced chemical reaction with state symbols (1 mark)

ii) The Haber process is described as being in equilibrium. What does this mean? **2**
When the rate of forward reaction equals the rate of reverse reaction (1 mark) and the concentrations are constant (1 mark).

iii) Iron is used as a catalyst in the Haber process. **1**
What term can be used to describe this type of catalyst?

Heterogeneous

iv) A small scale production was carried out in a one litre flask. The following concentrations were found at equilibrium: N_2 (4 mol.l^{-1}), H_2 (2 mol.l^{-1}) and NH_3 (6 mol.l^{-1}) **3**

Write an equilibrium constant equation for the process and then use the data to calculate the equilibrium constant K (with units) for the reaction.

$$K = \frac{[NH_3]^2}{[N_2] \times [H_2]^3}$$ ***(1 mark)***

$$K = \frac{[6]^2}{[4] \times [2]^3}$$ ***(1 mark)***

$$K = \frac{6^2}{4 \times 2^3}$$

$$K = \frac{36}{32}$$

$K = 1.125$ ***(1 mark)***

v) The Haber process is governed by Le Chatelier's principle. Define this principle. **1**
A system (reaction) at equilibrium will oppose any change applied to it.

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v) Explain, in detail, what would happen to the yield of ammonia if 1) the pressure was increased, and 2) the temperature increased. **4**

Pressure

Increases (1 mark). There are more gas molecules on the left-hand side of the arrows, so they will collide and shift the equilibrium to the right to lower the pressure and so increase the yield of ammonia. (1 mark)

Temperature

Decreases (1 mark). The forward reaction is used to make ammonia. It is an exothermic reaction. The reverse reaction is endothermic. Increasing the temperature will shift the equilibrium to the left, so decreasing the yield of ammonia. (1 mark)

b) The Haber process is an exothermic process. Use the following table of bond enthalpies to work out the overall enthalpy value for the Haber Process. **3**

Bond	Bond enthalpy ($kJmol^{-1}$)
$N\equiv N$	945
N—H	388
H—H	436

Bonds broken

break 1moles of NN bonds = 1x945=945
break 3moles of HH bonds = 3x436=1308
2253

Bonds formed

form 6 moles of NH bonds = 6 x -388= -2328

Overall ***ΔH =2253 + (-2328) = -75kJ.mol⁻¹*** $\Delta H = 2253 + (-2328) = -75 kJ.mol^{-1}$

Working 2 marks
Answer with correct sign and units 1 mark

c) Ammonia gas dissolves in water to form a 'weak base' solution. The chemical reaction for this is: $NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH_4OH_{(aq)}$

i) Define what is meant by a 'weak base'. **2**

Base is a proton acceptor (1)
Weak bases don't completely ionise/dissociate (1)

ii) As well as weak bases there are weak acids. Ethanoic acid (CH_3COOH) is found in vinegar and is a weak acid. Calculate the pH of a 0.135 $mol.l^{-1}$ solution of ethanoic acid if its ka is 1.7×10^{-5}. **2**

Work out pKa (1 mark)

$pKa = -log_{10} Ka$
$= -log_{10} (1.7 \times 10^{-5})$
$= 4.76$

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Marks

<u>Work out pH (1 mark)</u>

pH= ½pKa - ½log$_{10}$C
= ½(4.76) - ½log$_{10}$[0.135]
= 2.38 - ½(-0.869)
= 2.38 - (-0.435)
=2.815 (2.82)

Total 20 Marks

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Marks

Question 3

a) Transition metal elements and the complexes they form play a crucial role in chemistry.

i) What is the definition of a transition metal? **1**

Metals with an incomplete d-subshell in at least one of their ions.

ii) State the electronic configuration (spectroscopic) for Ni^{2+}. **1**

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$ or $[Ar]3d^8$

iii) The level of nickel ions in a solution can be calculated using a complexometric titration. In a titration, a 20.0 cm^3 sample of a nickel(ii) ion solution required 17.0 cm^3 of 0.1 mol. l^{-1} EDTA to completely react with all the nickel(ii) ions. **3**

What is the concentration of the nickel (ii) ion solution in mol.l^{-1}?

Method

C_1=EDTA

C_1= 0.1 mol. l^{-1}

V_1= 17.0cm^3

n_1= 1

C_2=Ni^{2+} ion solution

C_2=?????????

V_2=20.0cm^3

n_2= 1

$$\frac{C_1V_1}{n_1} = \frac{C_2V_2}{n_2}$$

(1 mark for equation or correctly attaching values to parts of the equation - see above)

$$C_2 = \frac{C_1 \times V_1 \times n_2}{V_2 \times n_1}$$

$$C_2 = \frac{0.1 \times 17.0 \times 1}{20.0 \times 1}$$

(1 mark for working)

C_2= 0.085 mol.l^{-1} ***(1 mark for correct answer and units)***

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Alternative method

Moles of EDTA = concentration x volume

$$= 0.1 \times \frac{17.0}{1000}$$
$$= 0.1 \times 0.0170$$
$$= 0.0017 \text{ moles}$$ ***(1 mark)***

From mole ratio

1 mole EDTA reacts with 1 mole Ni^{2+} ion solution

0.0017 moles EDTA reacts with 0.0017 moles Ni^{2+} ion solution (1 mark)

Molar Concentration Ni^{2+} ion = moles / volume

$$= \frac{0.0017}{0.020}$$
$$= 0.085 \text{ mol. } l^{-1}$$ ***(1 mark)***

iv) Like nickel, manganese is a transition metal with many oxidation states. Complete the table by working out the oxidation state of manganese in each of these different chemical species. **2**

Chemical species	Oxidation state
$KMnO_4$	
MnO	

Chemical species	Oxidation state
$KMnO_4$	***7+***
MnO	***2+***

b) Transition metal ions are found at the centre of many transition metal complexes where they are attached to ligands.

i) What type of bond do ligands form with the transition metals ions in these complexes? **1**

Dative bonds

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Marks

ii) Complete the following table which contains information about a number of different transition metal-ligand complexes. **3**

Formula of transition metal-ligand complex	**Name**
$Na_3[Fe(CN)_6]$	
	Tetraamminecopper (II) chloride
$[Ni(NH_3)_6]Cl_2$	

Formula of transition metal-ligand complex	**Name**
$Na_3[Fe(CN)_6]$	***Potassium hexacyanoferrate(III) (1 mark)***
$[Cu(NH_3)_4]Cl_2$ (1 mark)	Tetraamminecopper (II) chloride
$[Ni(NH_3)_6]Cl_2$	***Hexaaminenickel(II) chloride (1 mark)***

c) Explain how transition metal complexes can be coloured. **4**

Each ligand binds to the transition metal ion and "splits" its d orbitals into low and high energy orbitals. (1 mark)

The level of "splitting" depends on the ligand or ligands split differently depending on their position in the "Spectrochemical Series". (1 mark)

Electrons in the low energy d-orbitals absorb energy from the visible part of the electromagnetic spectrum and move to the high energy d-orbitals. (1 mark)

The absorb energy corresponds to certain colours in the visible range. The remaining colours are transmitted and this is the colour we see. (1 mark)

d) Nickel can be used as a catalyst in a number of organic reactions.

i) Ethene (C_2H_4) can be converted into ethane (C_2H_6) using hydrogen and the catalyst nickel. What type of reaction is this? **1**

Reduction or hydorgenation

ii) Ethene can also undergo a bromination reaction to form 1,2-dibromoethane. Write a mechanism for this reaction. **4**

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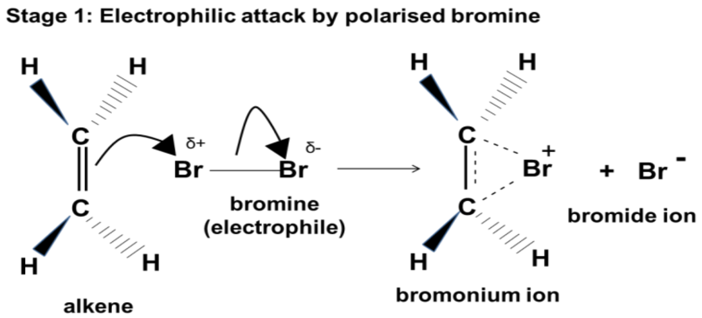
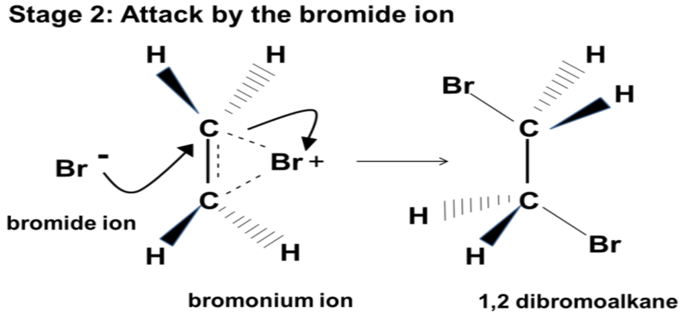
Marks



1 mark for polarisation of bromine bond and 1 mark curly arrow from correct ethene structure



1 mark for correct curly arrows in bromonium ion and 1 mark for correct final 1,2-dibromoethane structure

Total 20 Marks

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Marks

Question 4

a) Calcium carbonate reacts with hydrochloric acid to give calcium chloride, carbon dioxide and water. In the reaction 10g of calcium carbonate powder was reacted with 50 cm^3 of 0.1 $mol.l^{-1}$ hydrochloric acid.

$$CaCO_{3\ (s)} + 2HCl_{\ (aq)} \longrightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

i) How many moles of calcium carbonate and hydrochloric acid were involved in this reaction? Show all of your working. **4**

<u>Calcium carbonate</u>
GFM=100g (1 mark)
n= mass/GFM=10g/100g=0.1 moles (1 mark)

<u>Hydrochloric acid</u>
Volume =50/1000=0.05 litres (1 mark)
n= CxV= 0.1 x 50/1000 =0.005 moles (1 mark)

ii) The following results were obtained from the reaction. Work out the rate of reaction between two and four minutes. **2**

Time **(minutes)**	0	2	4	6	8	10
Total volume of carbon dioxide production **(cm^3)**	0	42	68	78	92	104

Rate = $\dfrac{68-42\ cm^3}{4-2\ minutes}$ ***= 13.0*** $cm^3\ min^{-1}$
(1 mark) (1 mark)

iii) What individual changes could you make to the reaction set-up in order to decrease the rate of this reaction? **3**
Decrease concentration of hydrochloric acid (1 mark)
Decrease the temperature of the reaction (1 mark)
Increase the particle size of calcium carbonate i.e. use chips instead of powder (1 mark)

iv) Explain how the changes in iii) would slow down the rate of the reaction. **1**
All three of the above changes will lower the number of successful collisions

b) Reactions can be termed as either exothermic or endothermic. The following reaction is exothermic.

$$H_{2\ (g)} + O_{2\ (g)} \longrightarrow H_2O_{\ (l)}$$

i) What is meant by the term exothermic? **1**
Reaction that releases heat energy.

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Marks

ii) Draw a diagram representing the range of molecular energies in a gas. **2**

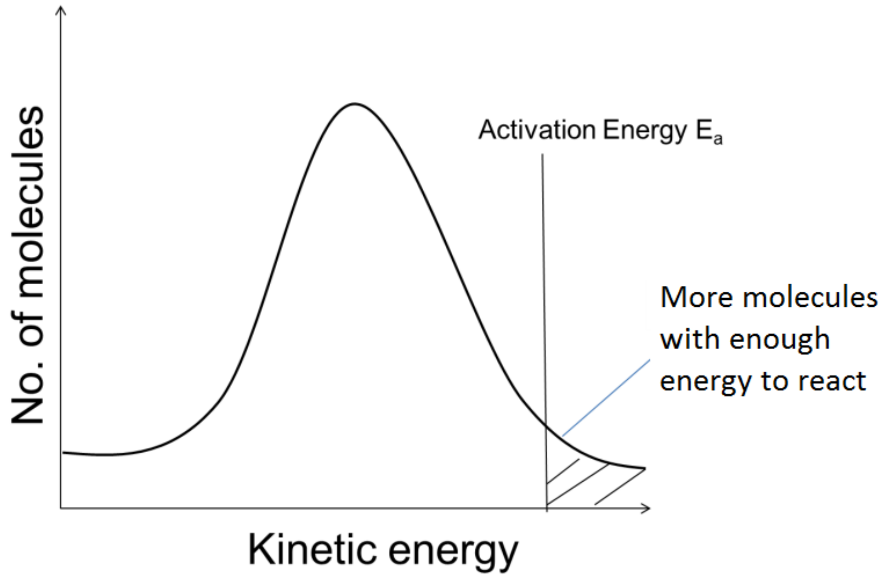
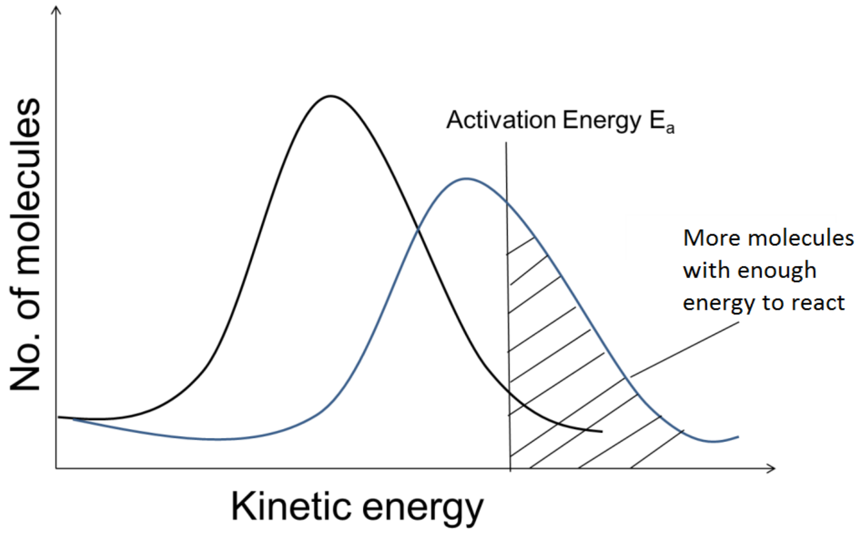


Diagram (1)
Labels (1)

iii) On the same diagram, draw a curve to represent the energies of the gas molecules when the temperature is increased by 10ºC. **1**



iv) Platinum can be used as a catalyst in this reaction. Use your diagram, adding on any features you think appropriate, to explain the effect a catalyst has on the rate of the reaction. **2**

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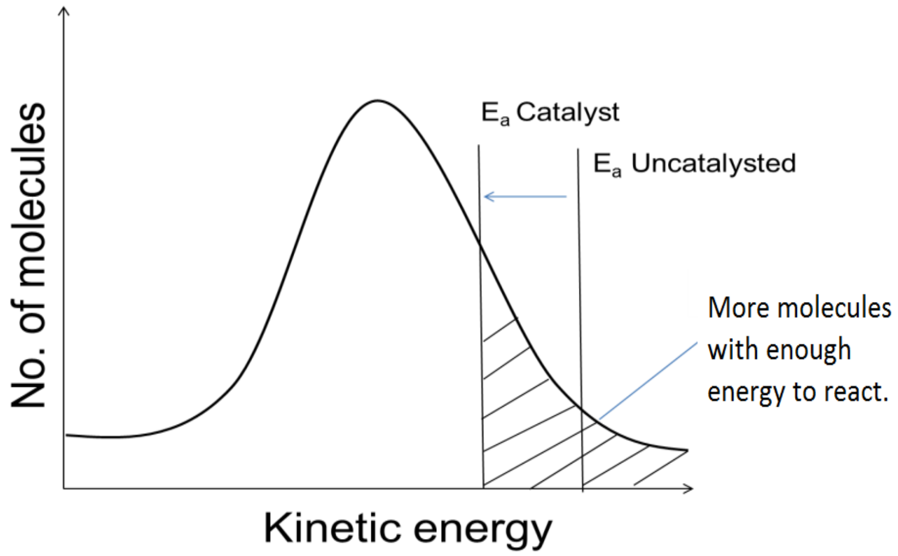

Diagram showing a shift (downwards) for the Ea (1 mark) and a greater population of molecules with enough energy to react (1 mark).

v) Explain why a catalyst has no effect on the enthalpy (heat) of reaction. **1**
The enthalpy of reaction is the difference in the energy between the reactants and products. A catalyst only lowers the activation energy of a reaction, not the enthalpy.

c) Reaction rate data can be used to investigate the kinetics of a chemical reaction. Below are the results from a kinetics experiment on the reaction between acidified potassium permanganate ($H^+/KMnO_4$) and hydrogen peroxide (H_2O_2).

Concentration of H_2O_2 (mol.l^{-1})	**Concentration of $H^+/KMnO_4$ (mol.l^{-1})**	**Initial Rate (mol.l^{-1}s^{-1})**
0.02	0.20	6.0×10^{-5}
0.02	0.40	1.2×10^{-4}
0.04	0.20	1.2×10^{-4}

i) What is the overall order of the reaction? **1**
Second order

ii) Write a rate equation for this reaction. **1**
rate =k[H^+/ $KMnO_4$] [H_2O_2]

iii) Use the information in the table above to work out a value for k. **1**
$6.0 \times 10^{-5} = k \times 0.2 \times 0.02$

$$\frac{6.0 \times 10^{-5}}{0.2 \times 0.02} = k$$

$k = 0.015$ mol^{-1}.l.s^{-1}

Total: 20 marks

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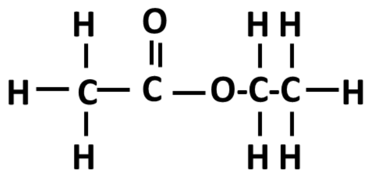
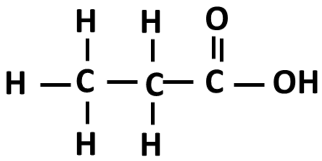
Question 5

a) A chemistry student finds a bottle with just the molecular formula, $C_3H_6O_2$, written on it. She is not sure whether the compound in the bottle is ethylethanoate or propanoic acid.

i) Draw full structural formulae for both compounds. **2**



Ethylethanoate (1 mark)

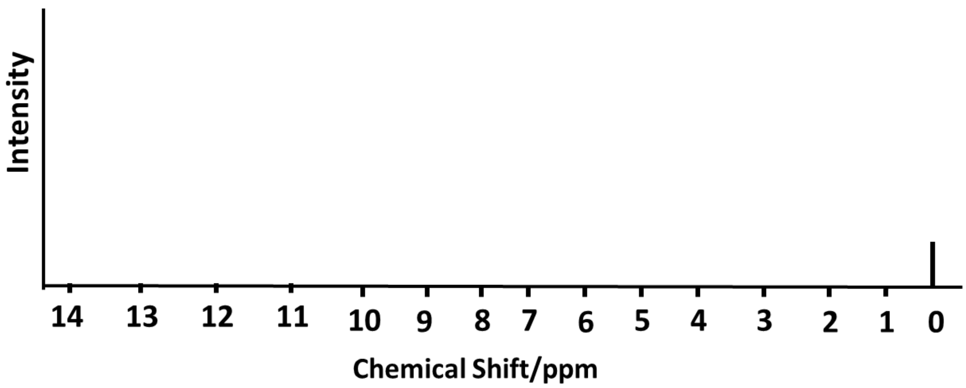


Propanoic acid (1 mark)

ii) Chemical analysis was carried out on the sample in the bottle. ^{1}H-NMR spectroscopy was chosen. **4**

Draw out the ^{1}H-NMR spectrum diagram and complete it to show what the high resolution ^{1}H-NMR spectra for propanoic acid would look. Make sure you have information about any splitting and include the reference compound TMS.

You may wish to use the chemical shift table found in the data sheet at the end of your examination paper.



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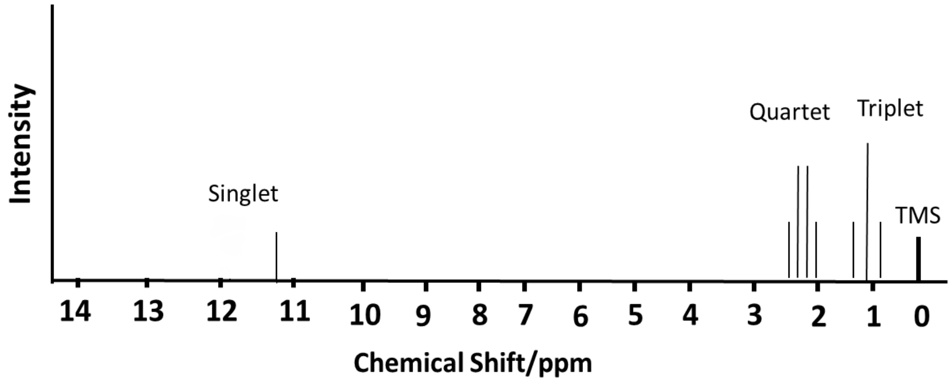
Marks



Triplet of peak area 3 due to CH_3 group (1 mark)

Quartet of peak area two due to $–CH_2$- group (1 mark)

Singlet of peak area 1 due to OH hydrogen (1 mark)

Peak areas in roughly the correct chemical shift positions (1 mark)

iii) A simple chemical test could also be used to tell the two suspected compounds apart. Suggest a simple chemical test that the chemist could have used. What observations would be made with each compound? **3**

<u>Test 1</u>
Either Universal Indicator or pH paper (1 mark)
Goes orange/yellow in propanoic acid (1 mark)
Stays green in propylethanoate (1 mark)

Or

<u>Test 2</u>
Use sodium carbonate/sodium hydrogencarbonate (1 mark)
Effervescence with propanoic acid (1 mark)
No reaction with ester. (1 mark)

iv) Ethyl ethanoate and propanoic acid do not contain a chiral carbon centre. What is a chiral centre? **1**
A carbon with four different groups attached to it.

v) Propanoic acid can be changed into propanal and propan-1-ol. **2**
What type of reaction is this and what reagent would be used to carry it out?
Reduction (1 mark) and Lithium aluminium hydride /$LiAlH_4$ (1mark)

b) Benzene is an aromatic compound that is found in a variety of different medicines, including aspirin. It can undergo a variety of electrophilic substitution reactions.

i) What shape is the benzene molecule? **1**
Planar

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Marks

ii) Give the reagents and conditions necessary for the conversion of benzene to nitrobenzene. **2**
Concentrated nitric acid and concentrated sulfuric acid. (1 mark) below 60ºC. (1 mark)

iii) Write a mechanism for this reaction using curly arrows. Explain what is happening at each stage including the formation of any ions. **5**

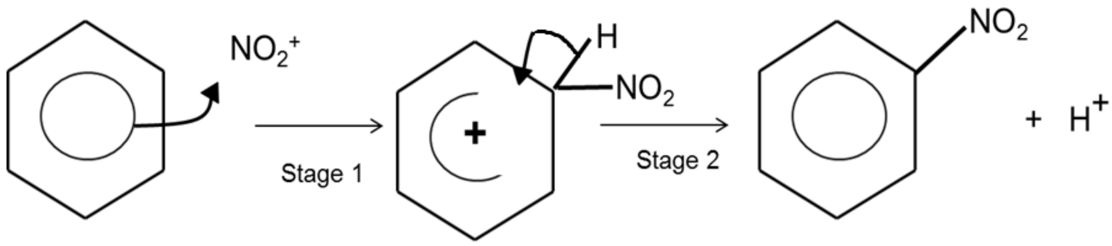

Diagram with correct placement of curly arrows and intermediate structure (2 marks)

Stage 1: Formation of nitronium ion and attack on benzene ring
Benzene reacts with nitric acid when a mixture of concentrated nitric acid and concentrated sulfuric acid (known as a nitrating mixture) is used below 60^{0}C. The nitrating mixture generates the nitronium ion, NO_2^+.

$HNO_3 + 2H_2SO_4 \longrightarrow NO_2^+ + 2HSO_4^- + H_3O^+$
(1 mark)

This ion attacks the benzene ring and delocalised electrons from the ring are attracted and form a new bond in an intermediate carbocation. (1 mark)

Stage 2: Formation of nitrobenzene
The benzene ring regains its aromatic stability by the removal of a hydrogen ion and the product molecule nitrobenzene is formed. (1 mark)

Total 20 Marks

End of paper

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Periodic Table with the mass number and atomic number of each element.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.008																	2 **He** 4.0026
3 **Li** 6.94	4 **Be** 9.0122											5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.085	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.630	33 **As** 74.922	34 **Se** 78.97	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.95	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89-103 #	104 **Rf** (265)	105 **Db** (268)	106 **Sg** (271)	107 **Bh** (270)	108 **Hs** (277)	109 **Mt** (276)	110 **Ds** (281)	111 **Rg** (280)	112 **Cn** (285)	113 **Nh** (286)	114 **Fl** (289)	115 **MC** (289)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (294)

* Lanthanide series	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
# Actinide Series	89 **Ac** (227)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

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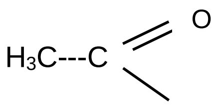
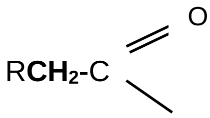
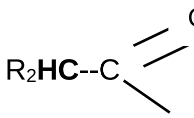
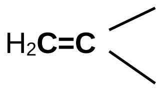
Nuclear Magnetic Spectroscopy data table

Approximate proton chemical shift values (δ) relative to TMS peak (0 on the scale)

Type of proton	Chemical Shift (ppm)
R----**CH_3**	0.9-1.1
R----**CH_2**----R	1.31.5
   Aldehyde, Ketone, CAcid and Ester fragment	2.0-.2.7
	4.8-5.0
R----CH_2---**X**	3.2-4.3
R----**OH**	4.0-4.5
R------**COOH**	11.0-11.3
R----**CHO**	9.8-10.2
Ar----CH_3	2.3-3.0
Ar----OH	7.0-7.3
Ar----H	7.4-7.6

R = alkyl group
Ar = aryl (aromatic) group
X = halogen

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Infrared Spectroscopy data table

Type of bond	Type of compound	Wave number range (cm^{-1})
hydrogen bonded O − H stretch not hydrogen bonded O − H stretch	Alcohol	3200 to 3570 33590 to 3570
C − H stretch C − H bend	Alkane	2853 to 2962 1340 to 1485
C − H stretch in C = C – H C = C stretch	Alkene	3010 to 3095 1620 to 1680
C=O stretch	Aldehyde, Ketones, Carboxylic acids and Esters	1680 to 1750
hydrogen bonded O − H stretch in −COOH	Carboxylic acids	2500 to 3500
 C-Br C-Cl	Halogenalkanes	 500 to 600 650-800
C − H stretch	benzene ring	3000 to 3100

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Formulae

$\Delta H = c \times m \times \Delta T$ (4·18 kJ kg^{-1} ºC^{-1})

% yield= $\frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$

% atom economy= $\frac{\text{Mass of desired product(s)}}{\text{Total mass of reactants}} \times 100$

$n = c \times V$

$\frac{C_1 \times V_1}{n_1} = \frac{C_2 \times V_2}{n_2}$

n= mxGFM

rate = $\frac{\Delta \text{quantity}}{\Delta \text{ time}}$

pH+ pOH=14

pH= $\log_{10} [H^+]$

$K_w = [H^+] \times [OH^-]$

$pK_a = \log_{10} K_a$

pH =1/2 pK_a -1/2 $\log_{10}$ [Concentration]

Physical constants

Avogadro's Constant 6·02 × 10^{23} mol^{-1}
Charge on electron 1·60 × 10^{-19} C

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Learning Outcomes Matrix

Question	Learning Outcomes assessed	Marker can differentiate between varying levels of achievement
1	1, 3	Y
2	2	Y
3	1, 3, 4, 5	Y
4	1, 2	Y
5	4, 5, 6, 7	Y

Grade descriptors for Chemistry

Learning Outcome	Pass	Merit	Distinction
Understand atomic structure and bonding	Demonstrate an adequate level of understanding	Demonstrate robust level of understanding	Demonstrate a highly comprehensive level of understanding
Understand energetics, rates, kinetics and chemical equilibria	Demonstrate an adequate level of understanding	Demonstrate robust level of understanding	Demonstrate a highly comprehensive level of understanding
Understand the key points of inorganic chemistry	Demonstrate an adequate level of understanding	Demonstrate robust level of understanding	Demonstrate a highly comprehensive level of understanding
Understand functional groups, naming organic compounds and isomerism	Demonstrate an adequate level of understanding	Demonstrate robust level of understanding	Demonstrate a highly comprehensive level of understanding
Understand organic synthesis reactions	Demonstrate an adequate level of understanding	Demonstrate robust level of understanding	Demonstrate a highly comprehensive level of understanding
Understand aromatic (arene) chemistry	Demonstrate an adequate level of understanding	Demonstrate robust level of understanding	Demonstrate a highly comprehensive level of understanding
Understand the techniques used in organic analysis	Demonstrate an adequate level of understanding	Demonstrate robust level of understanding	Demonstrate a highly comprehensive level of understanding

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