

Answer ALL the questions. Write your answers in the spaces provided.

1. (a) Consider the following table, which shows data for the reaction between reactants **A** and **B**.

Expt.	[A] / mol dm ⁻³	[B] / mol dm ⁻³	Rate / mol dm ⁻³ s ⁻¹
1	1.0	0.50	0.0020
2	0.50	0.50	0.0010
3	0.50	1.0	0.0040

- (i) Define the term **order of reaction**.

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(1)

- (ii) Determine, giving reasons, the orders of reaction with respect to **A** and **B**.

Hence write the rate equation for the reaction.

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(3)



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(iii) Calculate a value for the rate constant and give its units.

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(2)

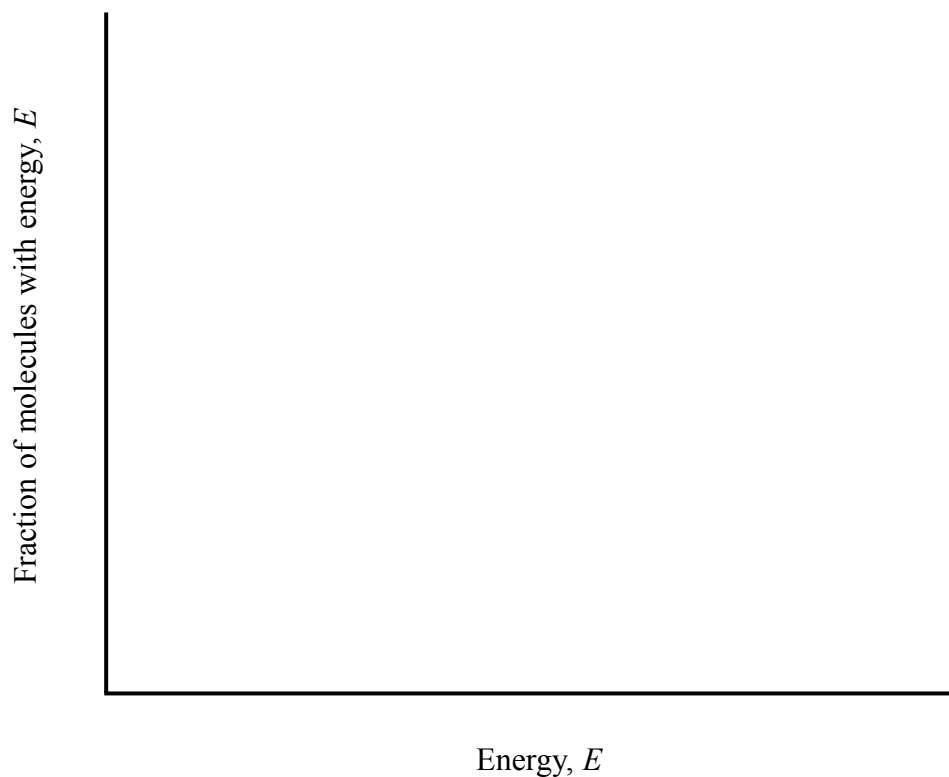
(iv) State how, if at all, the value of the rate constant would change if the temperature were increased.

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(1)



(b) (i) Draw a Maxwell-Boltzmann curve for a sample of a gas.



(1)

(ii) On your diagram mark and label the activation energies for a catalysed and uncatalysed reaction.

(1)

(iii) The rate of a reaction can also be increased by raising the temperature.

Describe how the Maxwell-Boltzmann curve at a higher temperature differs from the curve you have drawn in (i).

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(iv) Transition metals are important industrial catalysts.

Identify an industrial process involving a transition metal catalyst and name the catalyst used.

Explain why many transition metals and their compounds are successful catalysts.

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(3)

(v) How do the rate constants for the catalysed and uncatalysed reactions compare?

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(1)

(Total 15 marks)

Q1

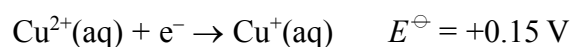
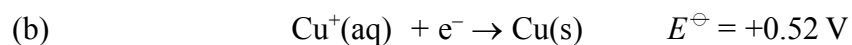
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2. (a) Identify the substances and conditions used in the standard chlorine half-cell.

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(3)



(i) Combine the half-equations above to produce the redox equation for the disproportionation reaction.

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(1)

(ii) Use the E^\ominus values to explain why this reaction is feasible.

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(2)

(iii) Explain why the above reaction can be classified as a **disproportionation** reaction.

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(2)

(c) Complete the electronic configuration for a copper(I) ion, Cu^+ .

$1s^2$

(1)



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(d) When excess concentrated ammonia solution is added to a solution of hydrated copper(II) ions, the complex $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ is formed.

(i) State the type of reaction occurring and give the colour of the complex.

Type Colour
(2)

(ii) Explain why this complex has a colour.

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(3)

(iii) Explain why copper(I) complex ions are **not** coloured.

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(2)

(e) When concentrated hydrochloric acid is added to an aqueous solution of Cu^{2+} ions, the complex CuCl_4^{2-} is formed.

Suggest the shape of this complex, state the bond angle and suggest why it has this shape.

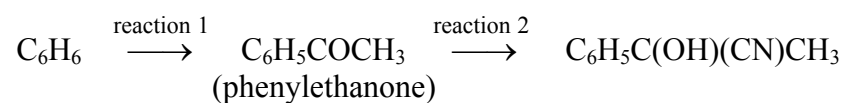
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(3)

(Total 19 marks)

Q2



3. This question concerns the following reaction scheme starting from benzene, C₆H₆.



(a) Explain why the low resolution n.m.r. spectrum of benzene contains only a single peak.

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(1)

(b) (i) Identify the reagent and the catalyst needed for **reaction 1**.

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(2)

(ii) What type of reaction is **reaction 1**?

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(1)

(iii) Draw the mechanism for **reaction 1**.

(4)



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(c) (i) Identify the reagents needed for **reaction 2**.

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(2)

(ii) What type of reaction is **reaction 2**?

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(1)

(iii) Draw the mechanism for **reaction 2**.

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(d) The product of **reaction 2** is a mixture of two isomers.

(i) Draw the structures of these two isomers, making their three-dimensional shape clear.

(1)

(ii) What would be the effect of this mixture on monochromatic plane-polarised light? Justify your answer by reference to your mechanism in (c)(iii).

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(3)

(e) How could infra-red spectroscopy be used to show that the product of **reaction 2** did **not** contain traces of the reactant phenylethanone?

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(1)

(Total 19 marks)

Q3

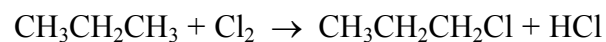


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N 2 4 7 0 1 A 0 1 1 1 6

4. (a) The following equation shows the reaction of propane with chlorine to produce 1-chloropropane.



- (i) Name the mechanism of the above reaction.

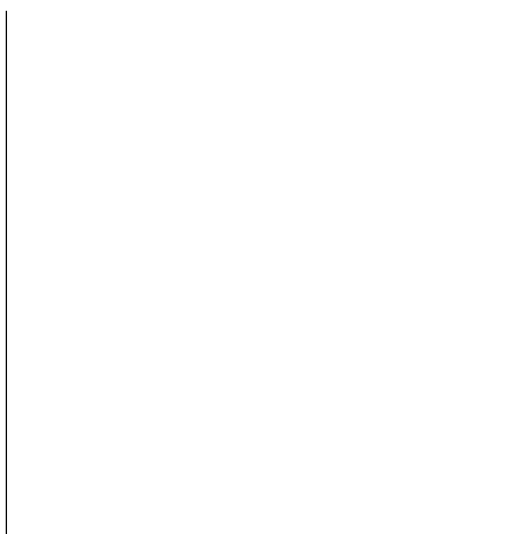
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- (ii) State ONE essential condition.

..... (1)

- (b) The boiling temperature of 1-chloropropane is 46 °C and that of 1-bromopropane is 71 °C.

Draw a boiling temperature/composition diagram for a mixture of these two substances. Use it to explain how fractional distillation could be used to separate this mixture.



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 (5)



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(c) Describe how to distinguish between pure samples of 1-chloropropane and 1-bromopropane using chemical tests.

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(d) Suggest which technique, mass spectrometry or low resolution n.m.r., would be more successful to distinguish between 1-chloropropane and 1-bromopropane. Justify your answer.

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(Total 15 marks)

Q4

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5. (a) An acidified solution of potassium manganate(VII) contains MnO_4^- ions, and can oxidise bromide ions, Br^- , to bromine.

It was found that 23.90 cm^3 of $0.200 \text{ mol dm}^{-3}$ potassium manganate(VII) solution was required to oxidise a solution containing 2.46 g of sodium bromide dissolved in dilute sulphuric acid.

Calculate the ratio of the number of moles of manganate(VII) ions reacting to the number of moles of bromide ions reacting.

Hence write the equation for the oxidation of bromide ions by manganate(VII) ions in acid solution.

(5)



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(b) Acidified potassium manganate(VII) solution can be safely stored in containers made of poly(ethene).

(i) Suggest a property of poly(ethene) which makes it suitable for the storage of this solution.

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(1)

(ii) Explain ONE environmental problem which may be caused by the disposal of a poly(ethene) container.

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(1)

Q5

(Total 7 marks)

TOTAL FOR PAPER: 75 MARKS

END



THE PERIODIC TABLE

Period **1** **2** **3** **4** **5** **6** **7** **0** Group

Period

1	H Hydrogen
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Molar mass g mol ⁻¹
Symbol
Name
Atomic number

4	He Helium
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7	Li Lithium	9	Be Beryllium
23	Na Sodium	24	Mg Magnesium
39	K Potassium	40	Ca Calcium
85	Rb Rubidium	88	Sr Strontium
133	Cs Caesium	137	Ba Barium
223	Fr Francium	226	Ra Radium

45	Sc Scandium	89	Y Yttrium	227	Ac Actinium
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48	Ti Titanium	51	V Vanadium	52	Cr Chromium	55	Mn Manganese	56	Fe Iron	59	Co Cobalt	59	Ni Nickel	63.5	Cu Copper	65.4	Zn Zinc
91	Zr Zirconium	93	Nb Niobium	96	Mo Molybdenum	99	Tc Technetium	101	Ru Ruthenium	103	Rh Rhodium	106	Pd Palladium	108	Ag Silver	112	Cd Cadmium
178	Hf Hafnium	181	Ta Tantalum	184	W Tungsten	186	Re Rhenium	190	Os Osmium	192	Ir Iridium	195	Pt Platinum	197	Au Gold	201	Hg Mercury
223	Fr Francium	226	Ra Radium	227	Ac Actinium	227	Ac Actinium	227	Ac Actinium	227	Ac Actinium	227	Ac Actinium	227	Ac Actinium	227	Ac Actinium

11	B Boron	12	C Carbon	14	N Nitrogen	16	O Oxygen	19	F Fluorine	20	Ne Neon
27	Al Aluminium	28	Si Silicon	31	P Phosphorus	32	S Sulphur	35.5	Cl Chlorine	40	Ar Argon
73	Ga Gallium	74	Ge Germanium	75	As Arsenic	79	Se Selenium	80	Br Bromine	84	Kr Krypton
115	In Indium	119	Sn Tin	122	Sb Antimony	128	Te Tellurium	127	I Iodine	131	Xe Xenon
204	Tl Thallium	207	Pb Lead	209	Bi Bismuth	210	Po Polonium	210	At Astatine	222	Rn Radon

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27	Al Aluminium	28	Si Silicon	31	P Phosphorus	32	S Sulphur	35.5	Cl Chlorine	40	Ar Argon
73	Ga Gallium	74	Ge Germanium	75	As Arsenic	79	Se Selenium	80	Br Bromine	84	Kr Krypton
115	In Indium	119	Sn Tin	122	Sb Antimony	128	Te Tellurium	127	I Iodine	131	Xe Xenon
204	Tl Thallium	207	Pb Lead	209	Bi Bismuth	210	Po Polonium	210	At Astatine	222	Rn Radon

140	Ce Cerium	141	Pr Praseodymium	144	Nd Neodymium	150	Sm Samarium	157	Gd Gadolinium	163	Dy Dysprosium	167	Er Erbium	169	Tm Thulium	173	Yb Ytterbium	175	Lu Lutetium
58	Ce	59	Pr	60	Nd	62	Sm	64	Gd	66	Dy	68	Er	69	Tm	70	Yb	71	Lu

232	Th Thorium	231	Pa Protactinium	238	U Uranium	242	Pu Plutonium	247	Cm Curium	251	Cf Californium	253	Fm Fermium	256	Md Mendelevium	257	Lr Lawrencium
90	Th	91	Pa	92	U	94	Pu	96	Cm	98	Cf	100	Fm	101	Md	103	Lr

