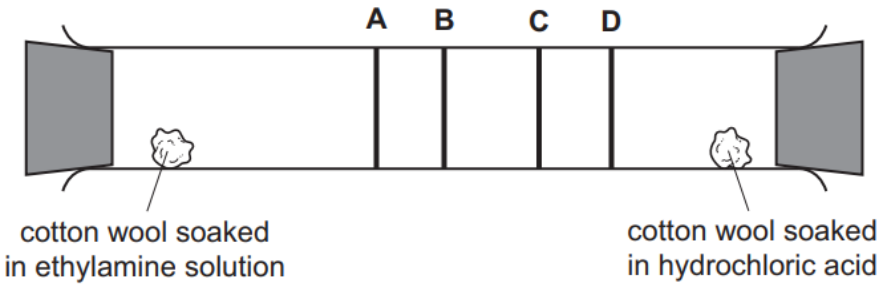
1 Ethylamine gas, $C_2H_5NH_2$, and hydrogen chloride gas, HCl, react together to form a white solid, ethylamine hydrochloride.

At which position in the tube would a ring of solid white ethylamine hydrochloride form?



2 Bromate ion, bromide ion and hydrogen ions react according to the equation shown.

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$

Some apparatus for measuring the change in the rate of this reaction is suggested.

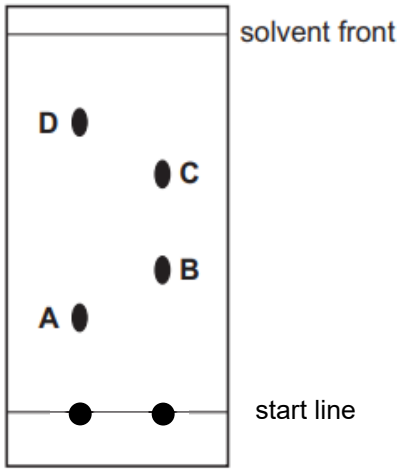
1 gas syringe
2 balance
3 pH meter

Which apparatus is suitable to measure the rate of this reaction?

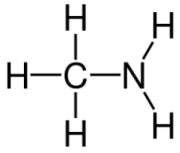
A 1 only
B 3 only
C 1 and 2
D 2 and 3

3 Some substances may be separated using paper chromatography. The diagram shows the results of running two mixtures in a suitable solvent.

Which spot has an R_f value of 0.4?



4 The diagram shows the structural formula of methylamine.



What is the total number of electrons involved and **not** involved in the bonding of methylamine molecule?

	Total number of electrons involved in bonding	Total number of electrons **not** involved in bonding
A	6	4
B	6	6
C	12	4
D	12	6

5 Both calcium chloride and potassium chloride are ionic compounds.

Which statement about these compounds is correct?

A Potassium chloride has a higher melting point than calcium chloride because the potassium ion has a greater charge than calcium ion.

B Calcium chloride and potassium chloride conduct electricity because positive and negative ions flow through the solid material.

C Molten calcium chloride has a greater electrical conductivity than molten potassium chloride because calcium contributes more electrons to the delocalised ‘sea of electrons’ than potassium.

D In the calcium chloride lattice, the ratio of calcium ions to chloride ions is half that of the ratio of potassium ions to chloride ions in the potassium chloride lattice.

6 Which sample contains the same number of the named particles as the number of molecules in 35.5 g of chlorine?

A atoms in 16 g of sulfur

B atoms in 23 g of sodium

C molecules in 32 g of methane

D molecules in 88 g of carbon dioxide

7 Sodium carbonate reacts with dilute hydrochloric acid.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

A sample containing 0.0800 mol of sodium carbonate is added to a solution containing 0.100 mol of hydrochloric acid.

What volume of carbon dioxide is produced at room temperature and pressure?

A 0.96 dm^3
B 1.20 dm^3
C 1.92 dm^3
D 2.40 dm^3

8 Which statement about acids and bases is correct?

A A 0.1 mol/dm^3 solution of ethanoic acid has a higher pH than a 0.1 mol/dm^3 solution of hydrochloric acid.
B All bases dissolve in water to produce OH^- ions.
C All oxides of non-metals are acidic in nature.
D Bases react with nitrates to produce ammonia.

9 Two solutions are prepared.

- Solution P is 0.050 mol/dm^3 hydrochloric acid.
- Solution Q is 0.100 mol/dm^3 butanoic acid.

A 2 cm strip of magnesium ribbon is put into 100 cm^3 of each solution. Fizzing is seen in both solutions but the fizzing is faster in solution P than in solution Q.

Which statement helps to explain this observation?

A Magnesium reacts with solution P to form a salt, but does not form a salt with solution Q.
B More particles are dissociated in solution P than are dissociated in solution Q.
C Solution P is a strong acid while solution Q is a weak acid.
D The particles are closer together in solution Q than they are in solution P.

10 Reactions 1, 2 and 3 are used in the manufacture of three fertilisers which are underlined in the equations.

Reaction 1: $H_2SO_4 + 2NH_3 \rightarrow \underline{(NH_4)_2SO_4}$

Reaction 2: $2H_2SO_4 + Ca_3(PO_4)_2 \rightarrow \underline{Ca(H_2PO_4)_2} + 2CaSO_4$

Reaction 3: $3H_2SO_4 + Ca_3(PO_4)_2 + 6NH_3 \rightarrow \underline{2(NH_4)_3PO_4} + 3CaSO_4$

The relative molecular mass, M_r, of sulfuric acid and of each fertiliser is shown in the table.

	H_2SO_4	$(NH_4)_2SO_4$	$Ca(H_2PO_4)_2$	$(NH_4)_3PO_4$
M_r	98	132	234	149

In each reaction, 98 g of sulfuric acid was used.

Which reaction gives the greatest and least mass of fertiliser?

	greatest mass	**least mass**
A	1	2
B	1	3
C	2	1
D	3	2

11 Tests were carried out on an aqueous solution of an unknown compound, P.

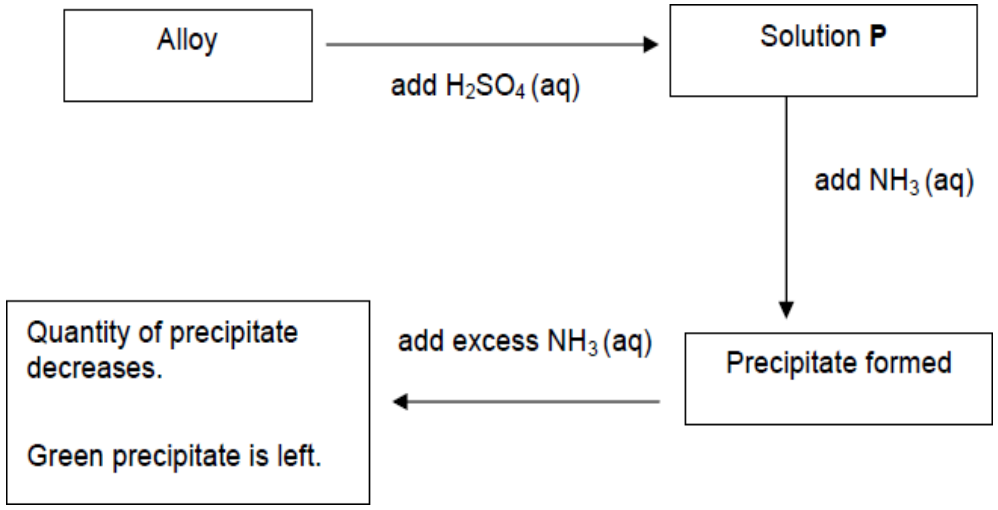
The observations are recorded in the table.

test	observation
aqueous sodium hydroxide added	green precipitate, soluble in excess giving a green solution
dilute nitric acid added then aqueous barium nitrate	white precipitate
dilute nitric acid added then aqueous silver nitrate	no precipitate

Which ions are present in P?

A Cr^{3+} and Cl^-
B Cr^{3+} and SO_4^{2-}
C Fe^{2+} and Cl^-
D Fe^{2+} and SO_4^{2-}

12 A sample of an alloy containing two metals was subjected to several tests as shown.



Which two metals are present in the alloy?

A iron and aluminium
B iron and lead
C iron and zinc
D lead and zinc

13 The steps for the preparation of a pure sample of sodium nitrate are listed.

1 Titrate with dilute nitric acid until the end-point is seen.
2 Evaporate to concentrate the solution.
3 Rinse out the conical flask.
4 Add indicator.
5 Pipette a known volume of aqueous sodium hydroxide into a conical flask.
6 Cool and filter to remove crystals.
7 Repeat using the same volumes of aqueous sodium hydroxide and dilute nitric acid but no indicator.

Which order of steps is correct?

A $1 \rightarrow 7 \rightarrow 5 \rightarrow 4 \rightarrow 2 \rightarrow 6 \rightarrow 3$
B $3 \rightarrow 5 \rightarrow 7 \rightarrow 1 \rightarrow 2 \rightarrow 4 \rightarrow 6$
C $4 \rightarrow 1 \rightarrow 3 \rightarrow 5 \rightarrow 2 \rightarrow 6 \rightarrow 7$
D $5 \rightarrow 4 \rightarrow 1 \rightarrow 3 \rightarrow 7 \rightarrow 2 \rightarrow 6$

14 In each of three experiments, a halogen was added to separate solutions containing ions of one of the other two halogens. The table shows the results.

Experiment	Halogen added	Solution of halide		
		U^-	V^-	W^-
1	U_2		No reaction	Reaction occurs
2	V_2	Reaction occurs		Reaction occurs
3	W_2	No reaction	No reaction	

What were the halogens U, V and W?

	U	V	W
A	Br_2	Cl_2	I_2
B	Br_2	I_2	Cl_2
C	Cl_2	Br_2	I_2
D	Cl_2	I_2	Br_2

15 The table gives properties of four metals, P, Q, R and S.

	method of extraction	reaction with water or steam	reaction with acid
P	electrolysis only	no reaction with water	reacts slowly
Q	heating oxide with carbon	reacts slowly with steam	reacts slowly
R	electrolysis only	reacts rapidly with steam	reacts rapidly
S	heating oxide with carbon	no reaction with water	no reaction

Which statement is correct?

A P is the least reactive.
B Q would displace R from a solution of its salt.
C R could be zinc.
D S could be copper.

16 The proton number of caesium is 55.

Compared with lithium, the melting point of caesium is .....1..... and the reaction of caesium with water is .....2..... vigorous. The number of electron shells in caesium is .....3..... compared to lithium.

Which words correctly complete gaps 1, 2 and 3?

	1	2	3
A	higher	more	the same
B	higher	less	greater
C	lower	more	greater
D	lower	more	the same

17 Chemical reactions occur in the blast furnace during the extraction of iron.

Which of these types of reaction occur?

1 acid-base
2 combustion
3 redox

A 1 and 2 only
B 1 and 3 only
C 1, 2 and 3
D 2 and 3 only

18 Attaching pieces of magnesium to underground iron pipes can protect the iron from corrosion.

Which reaction protects the iron from corrosion?

A $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$
B $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$
C $Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$
D $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$

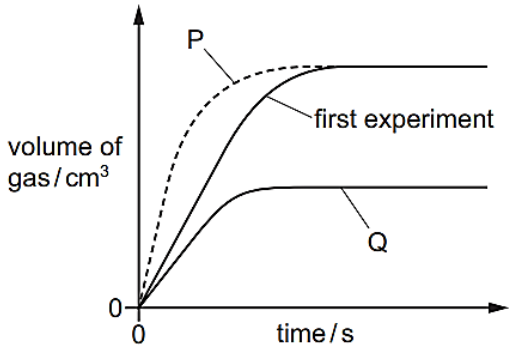
19 In the redox reaction shown, which row shows the correct change in the oxidation states of vanadium and sulfur?

$$VO_2^+ + SO_2 \rightarrow V^{3+} + SO_4^{2-}$$

	vanadium		sulfur	
	from	to	from	to
A	+1	+3	0	-2
B	+1	+3	+4	+6
C	+5	+3	0	-2
D	+5	+3	+4	+6

20 25 cm^3 of 1.0 mol/dm^3 hydrochloric acid reacts with 10 g of a solid to produce a gas. The solid is in excess.

The graph labelled first experiment shows the volume of gas produced over time. Graphs P and Q show the volume of gas produced under different conditions.



Which changes in conditions produce graphs P and Q, if all other conditions are kept the same?

A P uses a catalyst and Q has a lower temperature.
B P uses a higher temperature and Q uses 25 cm^3 of more dilute acid.
C P uses smaller pieces of solid and Q uses larger pieces of solid.
D P uses 25 cm^3 of more concentrated acid and Q uses smaller pieces of solid.

21 The table gives some information about four redox reactions.

Which row gives the correct information about what substance is oxidised and the evidence that it is oxidised?

	equation	substance oxidised in the reaction	evidence for this oxidation
A	$CuO(s) + C(s) \rightarrow CO(g) + Cu(s)$	copper	copper(II) oxide has lost oxygen to carbon
B	$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$	sodium	sodium atom lost an electron
C	$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	nitrogen	nitrogen has gained hydrogen
D	$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$	zinc	zinc atom has gained two electrons

22 Solution X is colourless. A few drops of aqueous potassium iodide are added to a small portion of X. No change is seen.

Solution Y is colourless. A few drops of aqueous acidified potassium manganate(VII) are added to a small portion of Y. The colour of the potassium manganate(VII) disappears.

What can be deduced about X and Y from these two observations?

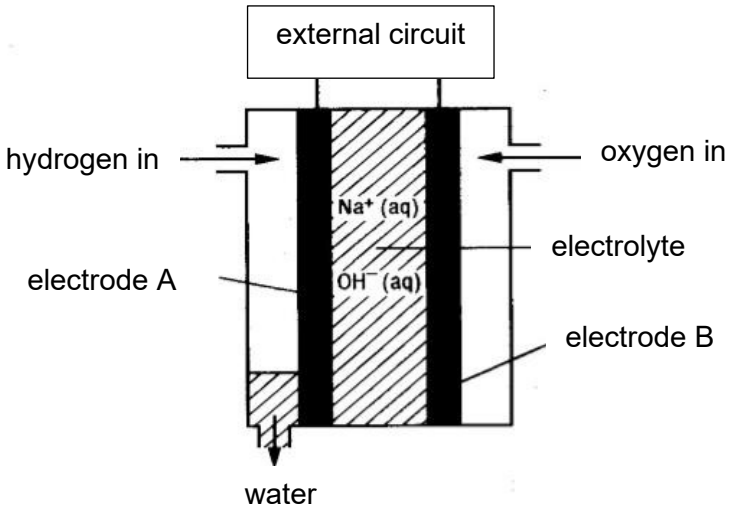
A X and Y are both reducing agents.
B X is an oxidising agent and Y is not a reducing agent.
C X is not a reducing agent and Y is an oxidising agent.
D X is not an oxidising agent and Y is a reducing agent.

23 When 100 g of an impure sample of zinc carbonate was heated to constant mass, the mass of the remaining solid obtained was 87.5 g.

What is the percentage purity of the zinc carbonate? Assume that the impurities do not decompose on heating.

A 12.5%
B 35.5%
C 65.1%
D 87.5%

24 The NASA space shuttle uses the following hydrogen-oxygen fuel cell to generate electricity.



Which of the following equations represents the reaction that occurs at the electrode B?

A $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$
B $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$
C $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$
D $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

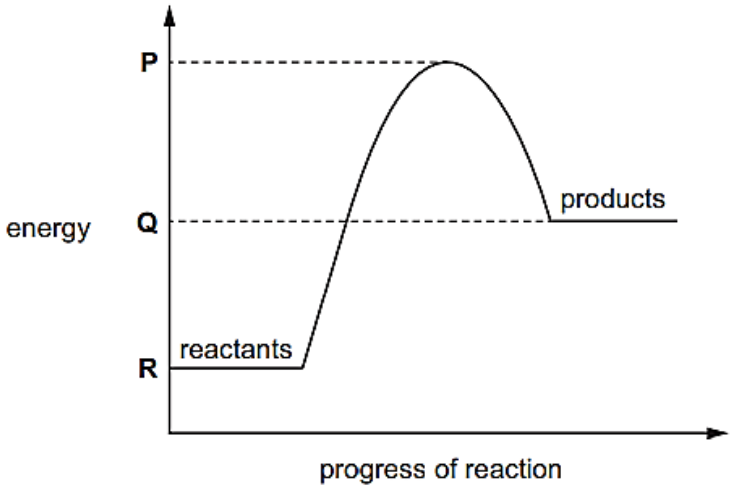
25 Approximately 40% of all iron and steel is produced by recycling. The following statements are possible reasons for recycling iron.

1 Recycling reduces the amount of waste taken to landfill sites.
2 Recycling reduces the amount of pollution at the site of the ore extraction.
3 Recycling reduces the need to collect the scrap iron and steel.
4 Scrap steel contains a higher percentage of iron than iron ore.

Which of the following statements are correct?

A 1 and 2 only
B 1, 2 and 3 only
C 1, 2 and 4 only
D 1, 2, 3 and 4

26 The diagram shows the energy profile diagram for a reaction.



Which statement is correct?

A It is endothermic and the activation energy is P – Q.
B It is endothermic and the activation energy is P – R.
C It is exothermic and the activation energy is P – Q.
D It is exothermic and the activation energy is P – R.

27 Gaseous phosphorus pentachloride, PCl_5, can be decomposed into gaseous phosphorus trichloride and chlorine by heating.

$$PCl_5\,(g) \rightarrow PCl_3\,(g) + Cl_2\,(g)$$

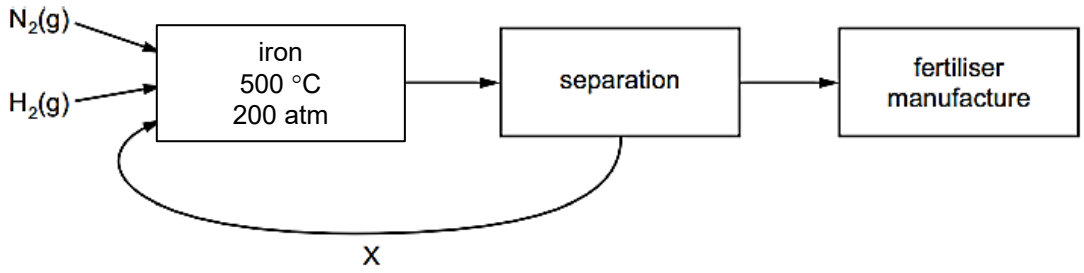
The table gives the bond energies.

Bond	Bond energy (kJ/mol)
P–Cl (in both chlorides)	330
Cl–Cl	240

What is the enthalpy change of the decomposition of phosphorus pentachloride?

A +90 kJ
B -90 kJ
C +420 kJ
D -420 kJ

28 The diagram shows the main stages in the manufacture of a fertiliser which is an ammonium compound.



What is happening in the process labelled X?

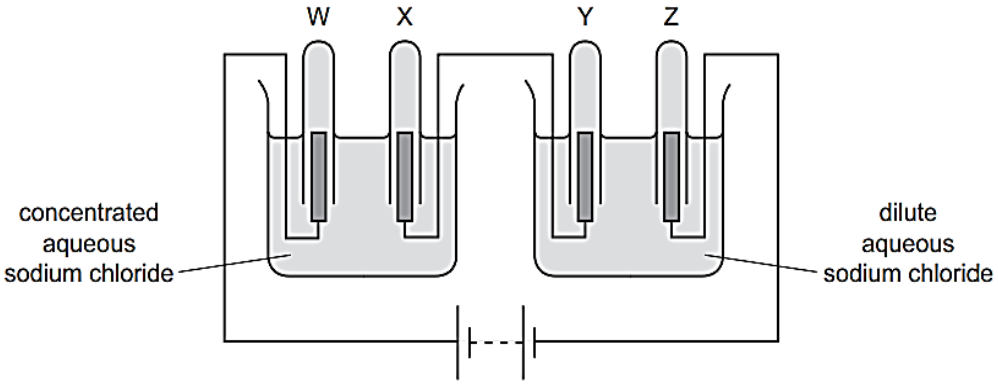
A Iron is recycled to increase the rate of reaction.
B The gases are cooled to cause ammonia to form a liquid.
C Unreacted nitrogen only is recycled.
D Unreacted hydrogen and nitrogen are recycled.

29 Dilute sulfuric acid is electrolysed. Hydrogen gas and oxygen gas are produced.

Which statement is correct?

	hydrogen produced at the	oxygen produced at the	concentration of acid
A	anode	cathode	decreases
B	anode	cathode	increases
C	cathode	anode	decreases
D	cathode	anode	increases

30 The diagram shows the electrolysis of concentrated and dilute aqueous sodium chloride using inert electrodes. Gases are produced and collected in each of the test-tubes W, X, Y and Z.



Which statements are correct?

1 Approximately equal volumes of gas are produced and collected in test-tubes W and X.
2 Approximately equal volumes of gas are produced and collected in test-tubes Y and Z.
3 Three different gases are produced in the experiment.

A 1 and 2 only
B 1 and 3 only
C 2 and 3 only
D 1, 2 and 3

31 One mole of each alkane undergoes complete combustion.

Which alkane will produce 7 moles of products?

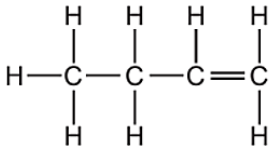
A CH_4 **B** C_2H_4 **C** C_2H_6 **D** C_3H_8

32 Which physical property of the alkanes does **not** increase as relative molecular mass increases?

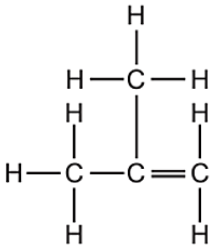
A boiling point
B flammability
C solubility in water
D viscosity

33 Three structures of hydrocarbon molecules are shown.

1



2



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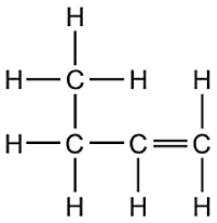


Which of the following statements is correct?

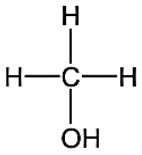
A 1 and 2 are identical.
B 1 and 3 are identical.
C They all have different densities.
D They are all saturated hydrocarbons.

34 Which statement applies to all three compounds ethane, ethene and ethanol?

A They are gases at room temperature and pressure.
B They contain oxygen atoms.
C They have the same number of hydrogen atoms per molecule.
D They have two carbon atoms per molecule.

35 The structures of four alcohols are shown.

1



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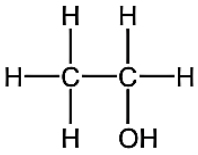

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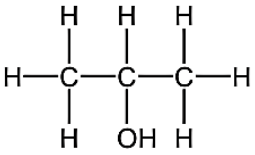

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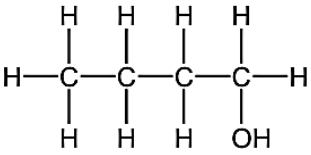


Which statement is correct?

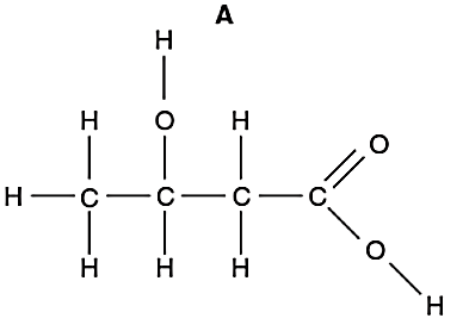
A Alcohol 1 can be made by the addition of steam to an alkene.
B Alcohol 2 is a product of fermentation.
C Alcohol 3 is a non-renewable energy source.
D Alcohol 4 has only one other isomer.

36 The table shows the results of tests carried out on compound X.

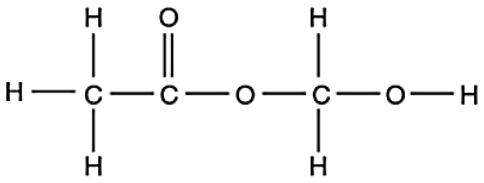
test	result
bromine water added	colourless solution formed.
sodium carbonate added	no visible change

Which structure represents compound X?

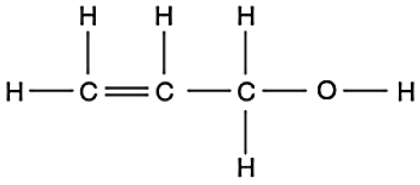
A



B



C



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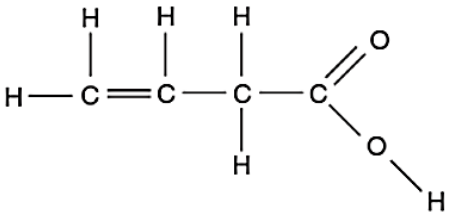
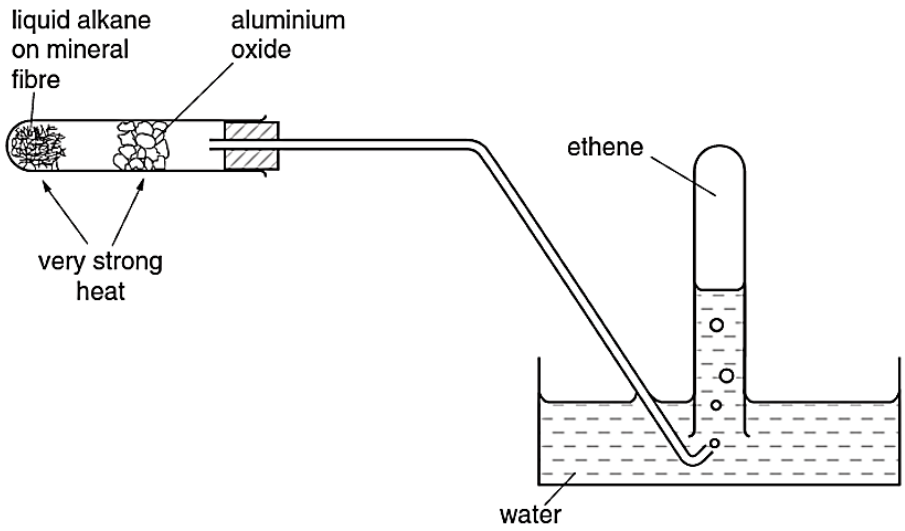


37 The experiment shown is carried out.



What process occurs?

A Cracking
B Esterification
C Fermentation
D Hydrogenation

38 Which bond is present in both nylon and Terylene?

A C – O **B** C = O **C** N – C **D** N – Cl

39 A catalytic converter in a car exhaust system speeds up the change of pollutants into less harmful products.

Which of the following changes does **not** occur in a catalytic converter?

A Carbon dioxide to carbon
B Carbon monoxide to carbon dioxide
C Nitrogen dioxide to nitrogen
D Unburnt hydrocarbons to carbon dioxide and water

40 Which statements about carbon monoxide is correct?

1 It is found in natural gas.
2 It is a product of incomplete combustion of petrol.
3 It can combine with haemoglobin in the blood.

A 1 and 2 only
B 1 and 3 only
C 2 and 3 only
D 1, 2 and 3

END OF PAPER

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	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 –		

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	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 –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Answer for 2023 Chemistry Prelim Paper 1

1	**A**	**21**	**B**
2	**B**	**22**	**D**
3	**B**	**23**	**B**
4	**D**	**24**	**D**
5	**D**	**25**	**C**
6	**A**	**26**	**B**
7	**B**	**27**	**C**
8	**A**	**28**	**D**
9	**C**	**29**	**D**
10	**B**	**30**	**B**
11	**B**	**31**	**D**
12	**C**	**32**	**B**
13	**D**	**33**	**B**
14	**A**	**34**	**D**
15	**D**	**35**	**B**
16	**C**	**36**	**C**
17	**C**	**37**	**A**
18	**D**	**38**	**B**
19	**D**	**39**	**A**
20	**B**	**40**	**C**

Section A (50 marks)
Answer all the questions.

A1 Choose from the following list of substances to answer the questions.

ammonium chloride
argon
butene
methane
phosphorus oxide
potassium nitrate
sulfur dioxide

Each substance can be used once, more than once, or not at all.

Name a substance which

(a) decomposes upon heating to produce an alkaline gas,

.....[1]

(b) decolourises bromine solution quickly,

.....[1]

(c) is found in natural gas,

.....[1]

(d) reacts with aqueous potassium hydroxide to form a salt,

.....[1]

(e) is used in electric bulbs to prevent corrosion of the tungsten filament.

.....[1]

A2 The table shows some of the ores of iron.

Iron ore	Formula of iron compound
Haematite	Fe_2O_3
Magnetite	Fe_3O_4
Siderite	$FeCO_3$

(a) Identify the iron compound which contains the greatest percentage by mass of iron.

Show the working for your answer.

[3]

(b) Like haematite, magnetite contains iron that can be extracted from it in a blast furnace.

(i) Write the chemical equation for the extraction of iron from magnetite in the blast furnace.

.....[1]

(ii) Explain, in terms of electrons, why iron in magnetite has been reduced.

.....

.....

.....[1]

(c) Iron is malleable. Explain this property in terms of its structure.

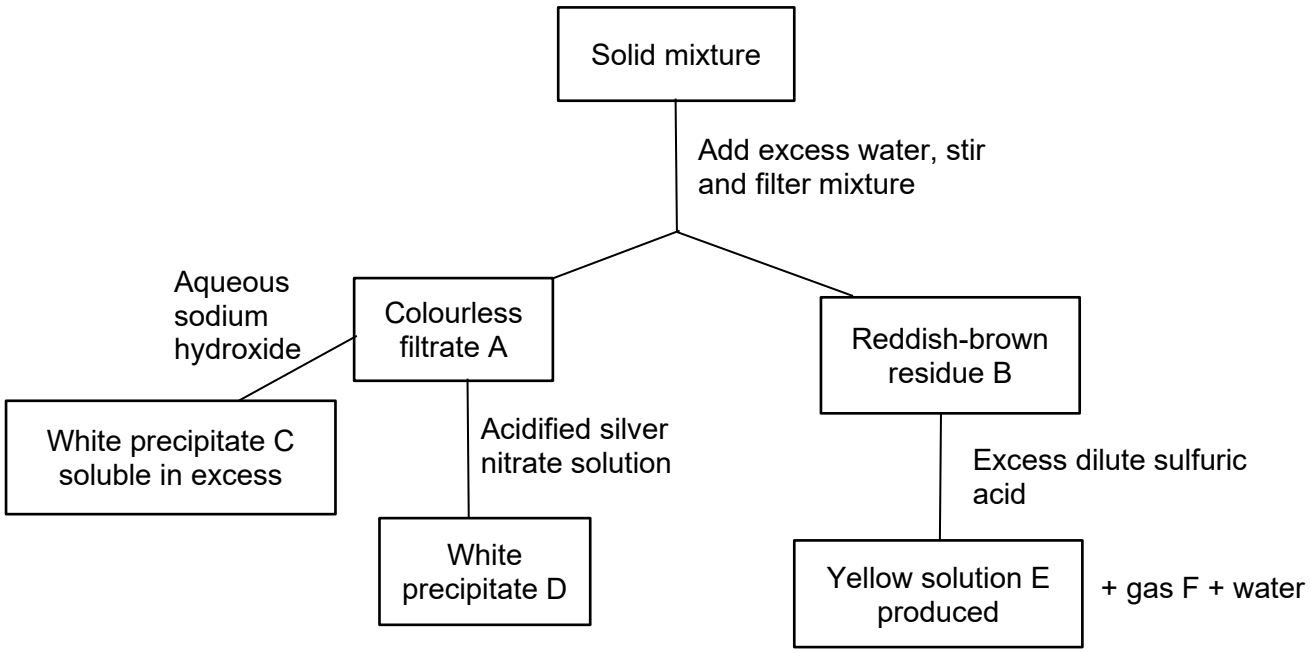
.....

.....

.....

.....[2]

A3 A series of experiments was carried out on a solid mixture consisting of two metal compounds.



(a) Name the following substances.

A: .....

B: .....

D: .....

E: ..... [4]

(b) Write the ionic equation for the formation of precipitate C.

..... [1]

(c) Describe the test for gas F.

.....

.....

.....

..... [2]

(d) Explain, using structure of substances, why B is a solid and F is a gas at room temperature and pressure.

.....

.....

.....

.....

.....

.....

.....[3]

A4 The Winkler method is a technique used to measure the amount of dissolved oxygen in freshwater systems. Dissolved oxygen is used as an indicator of the health of a water body, where higher dissolved oxygen concentrations are correlated with high productivity and little pollution. The concentration of dissolved oxygen can be determined by a series of reactions that is summarised by the equation.

$$2H_2O\,(l) + O_2\,(aq) + 4I^-\,(aq) \rightarrow 4OH^-\,(aq) + 2I_2\,(aq)$$

(a) When a 2000 cm^3 sample of river water was tested, 0.508 g of iodine was liberated.

(i) Calculate the concentration, in mol/dm^3, of dissolved oxygen in the river water sample.

[2]

(ii) Calculate the mass of oxygen that would be obtained if the same sample of river water was boiled.

[1]

(b) Explain, in terms of collision theory, the change in the rate of reaction when the concentration of dissolved oxygen increases.

.....

.....

.....

.....[2]

A5 Helium, neon, argon, krypton and xenon are noble gases.

(a) Use ideas about electronic structure to explain why the noble gases are unreactive.

.....

.....[1]

(b) Complete the table to show the number of particles in two isotopes of argon.

isotope	number of protons	number of electrons	number of neutrons
$^{36}_{18}\mathrm{Ar}$			
$^{40}_{18}\mathrm{Ar}$			

[2]

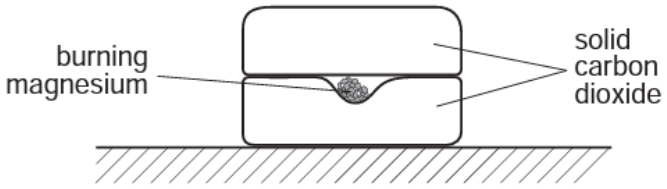
(c) Explain why calcium comes after argon in the Periodic Table even though it has a relative atomic mass which is equal to that of argon, $^{40}_{18}\mathrm{Ar}$.

.....

.....

.....[1]

A6 Several small pieces of magnesium are placed on a block of solid carbon dioxide. The solid carbon dioxide is at a temperature of -80°C. The magnesium is ignited and another block of solid carbon dioxide is immediately placed on top.



A vigorous reaction is observed.

$$2Mg + CO_2 \rightarrow 2MgO + C$$

(a) Suggest one observation that could be seen as the reaction proceeds to completion.

.....[1]

(b) State the condition that slows down the rate of reaction in this experiment.

.....[1]

(c) When 2 moles of magnesium react with one mole of carbon dioxide, 810 kJ of energy are released.

(i) Calculate the energy released when 2.0 g of magnesium reacts completely with carbon dioxide

[2]

(ii) Draw an energy level diagram for the reaction of magnesium with carbon dioxide.

[2]

(iii) Explain, in terms of the energy changes taking place in both bond-making and bond-breaking, why the reaction is exothermic.

.....

.....

.....

.....

.....[2]

(d) Do you think that the reverse reaction can take place?

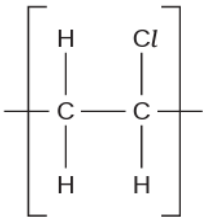
Explain your answer.

.....

.....

.....[1]

A7 Poly(chloroethene) is an addition polymer. It is often found in solid household waste. The diagram shows the repeat unit of poly(chloroethene).



(a) Draw the structure of the monomer used to make poly(chloroethene).

[1]

(b) One way to dispose of solid household waste is to burn it at a high temperature. The burning of poly(chloroethene) gives the waste gases hydrogen chloride, carbon dioxide and water.

(i) Hydrogen chloride gas is removed from the waste gases by reacting with moist powdered calcium carbonate.

Write the name and chemical formula of the solid product formed.

.....[1]

(ii) Draw the electronic structure of the calcium particle present in calcium carbonate. Show all the electrons.

[1]

(iii) Describe how a pure, dry sample of calcium carbonate could be obtained in the laboratory.

.....

.....

.....

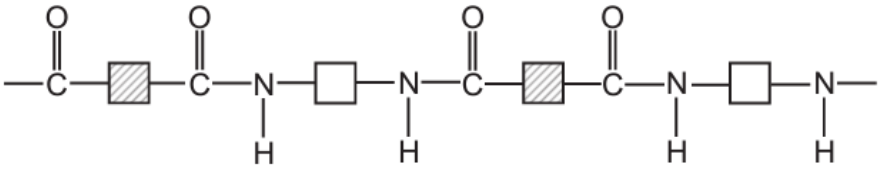
.....[3]

(c) Poly(ethene) is another polymer formed from addition polymerisation. Each molecule of poly(ethene) contains between 2000 and 20000 carbon atoms.

Calculate the range of mass of the poly(ethene) molecule.

[2]

(d) A structure of a polyamide is shown.



Draw the two monomers that make up this polymer.

[2]

Class	Index Number

Name: _____

Section B (30 marks)

Answer **all** three questions, the last question is in the form either/or.

Answer **all** the questions in the spaces provided.

B8 This question is about the effects of burning fossil fuels and clean energy.

The Taj Mahal, an iconic monument in India is slowly being eroded away. Preservationists believed that emissions from oil refinery plant nearby were causing acid rain that corroded the marble monument.

Chemists used an aqueous mixture of barium hydroxide and urea, $CO(NH_2)_2$, to treat the monument. As this solution soaks into the porous marble, the urea slowly hydrolyses forming ammonia and carbon dioxide. The carbon dioxide reacts with the barium hydroxide forming barium carbonate. Finally, surface barium carbonate on the treated monument can react with sulfur dioxide in the air, forming a layer of barium sulfate and carbon dioxide. This secondary reaction slows down the erosion process.

Table 1 shows the solubility of these substances in water.

Table 1

Substance	$CaCO_3$	$CaSO_4$	$BaCO_3$	$BaSO_4$
Solubility in water/ mol dm^{-3}	1.3×10^{-4}	4.5×10^{-2}	9.1×10^{-5}	9.4×10^{-6}

The negative effects of burning fossil fuels have created a need to look for alternative fuels. Hydrogen is a potential alternative to fossil fuel.

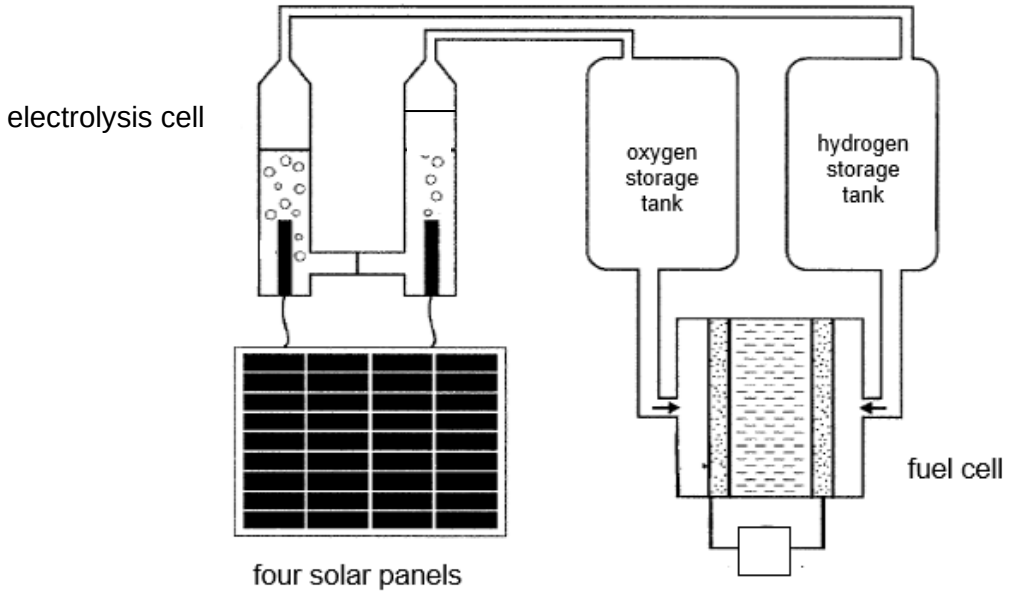
An article in the Straits Times on 11 Mar 2023 talked about 3 types of hydrogen – grey, blue and green hydrogen. Below is an excerpt of this article:

> Hydrogen is widely touted as a clean, non-polluting source of energy. But the problem lies in the process of extracting it from water during electrolysis that uses energy generated by greenhouse gas emitting fossil fuels for example methane. This is known as “grey hydrogen”, and accounts for as much as 99 per cent of hydrogen power in circulation today, said Mr Hidenori Saka of the New Energy and Industrial Technology Development Organisation (Nedo).
>
> “Blue hydrogen” is the intermediate grade. It is produced by reacting natural gas with steam. The emitted carbon dioxide is easily captured, stored and can be used to produce synthetic fuels. “Green hydrogen” in contrast is the cleanest.
>
> Nedo oversees the Fukushima Hydrogen Energy Research Field (FH2R) – a 220,000 sq m area largely occupied by 68,000 solar panels used to generate energy for electrolysis.

Figure 1 shows a simplified “green hydrogen” fuel cell which produces electricity using four solar panels.

Solar panels collect energy from the sun during daylight hours and this energy is used to electrolyse water to produce oxygen gas and hydrogen gas. These gases are stored separately and then used in a fuel cell to produce energy when required.

Figure 1



In Korea, cars powered by green hydrogen-oxygen fuel cells are gaining popularity. In Singapore, Comfort DelGro is committed to spend $6b to switch to Electric Vehicles.

Table 2 shows some information about a 200 km journey using an electric car and a fuel cell car. For the electric car to run, the battery needs to be re-charged while for a fuel cell car it needs to be refuelled with hydrogen gas.

Table 2

Type of car	Electric	Fuel cell
Charging time or refueling time /min	360	4
Cost of charging or refueling /S$	5.64	7.35
CO_2 emitted/kg	48	36
Mass of car/kg	1550	1200

(a) **(i)** Describe the formation of acid rain that corroded the marble monument.

.....

.....

.....

[2]

.....

(ii) Write the equation for the reaction between barium carbonate and sulfur dioxide, in the presence of oxygen.

[1]

.....

(iii) Explain how this method of treatment slows down the corrosion of Taj Mahal monument. Your answer should include the comparison of the solubilities of the substances in Table 1 and the reaction in **(a)(ii).**

.....

.....

.....

[2]

.....

(b) **(i)** Explain why “blue hydrogen” is preferred to “grey hydrogen”.

.....

.....

.....

[2]

.....

(ii) Explain why the set-up in Figure 1 is considered ‘green’.

.....

.....

[2]

.....

(iii) Explain how the fuel cell produces electricity.

.....

[1]

.....

(iv) Using the information in Table 2, state and explain the advantages, other than the amount of carbon dioxide emitted per kg, of using a car powered by a fuel cell to an electric car for the 200 km journey.

.....

.....

.....

.....

.....

[2]

.....

B9 Chlorine dioxide, ClO_2, was first obtained by Humphry Davy by the disproportionation reaction of chloric acid, $HClO_3$.

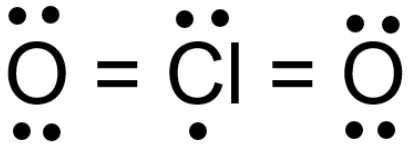
A disproportionation reaction is one where the same element is both oxidised and reduced in the reaction. The equation is as follows:

$$3HClO_3 \rightarrow 2ClO_2 + HClO_4 + H_2O$$

Although chlorine dioxide is unstable as a liquid or gas, it is now produced on a very large scale for the bleaching of wood pulp and for water treatment.

Figure 2 shows the Lewis structure of chlorine dioxide. Only the outer shell electrons are shown.

Figure 2



(a) Based on the structure, explain why chlorine dioxide is unstable as a liquid or gas.

.....

[1]

.....

(b) Explain, in terms of oxidation states, why the disproportionation reaction of chloric acid is a redox reaction.

.....

.....

.....

.....

[2]

.....

(c) **(i)** In the laboratory, chlorine dioxide is produced from the reaction between aqueous sodium chlorate ($NaClO_3$), solid oxalic acid $(COOH)_2$ and sulfuric acid. The other products are aqueous sodium sulfate, carbon dioxide and water.

Write a chemical equation for the reaction.

[1]

.....

(ii) State the type(s) of bonding present in sodium sulfate.

[1]

.....

(iii) 5.00 g of impure sample of hydrated oxalic acid, $(COOH)_2.2H_2O$, was dissolved in 1.00 dm^3 of water. 25.0 cm^3 of this solution was neutralised by 14.0 cm^3 of 0.100 mol/dm^3 sodium hydroxide using a suitable indicator.

The equation for the reaction is shown.

$$(COOH)_2(aq) + 2NaOH(aq) \rightarrow (COONa)_2(aq) + 2H_2O(l)$$

Calculate the percentage purity of the hydrated oxalic acid sample.

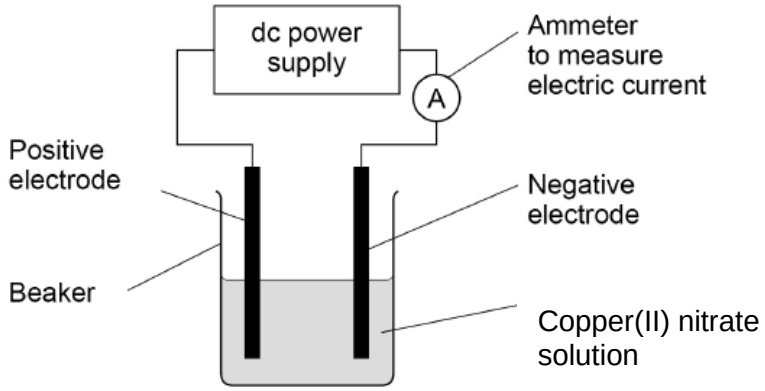
[3]

EITHER

B10 This question is about the electrolysis of aqueous copper(II) nitrate.

Some students investigated the electrolysis of copper(II) nitrate solution using inert electrodes. Figure 3 shows the apparatus.

Figure 3



The students investigated how the mass of copper produced at the negative electrode varies with time and current.

This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown.
3. Adjust the power supply until the ammeter shows a current of 0.3 A.
4. Switch off the power supply after 5 minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.

Repeat steps 1 to 7 at different currents.

(a) Write the ionic equation for the reaction at the negative electrode.

[1]

.....

(b) Some of the copper produced did not stick to the negative electrode but fell to the bottom of the beaker.

Suggest how the students could find the total mass of the copper produced.

.....

.....

.....

.....

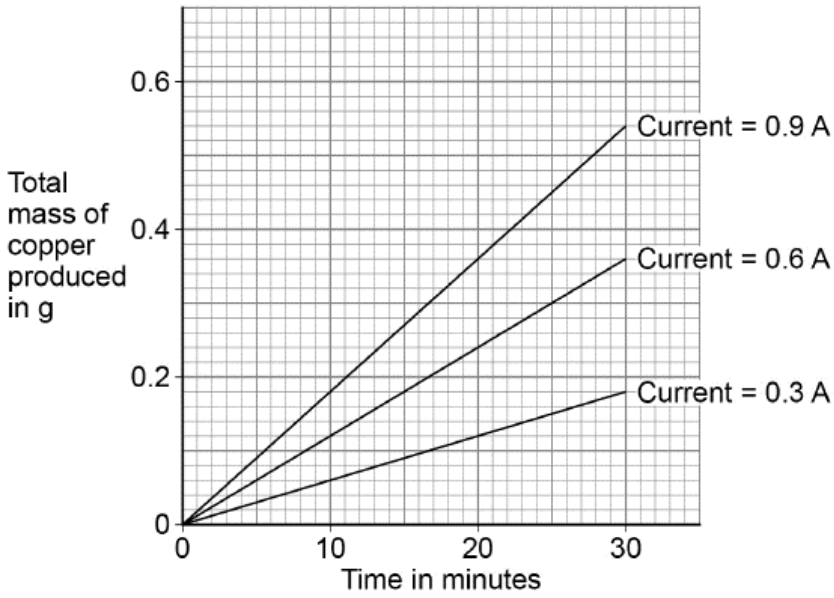
[3]

.....

(c) The student plotted their results on a graph.

Figure 4 shows the graph.

Figure 4



A student concludes that the total mass of copper produced is directly proportional to (i) the time taken and (ii) the current.

Do you agree? Justify your answer using the information given.

(i)

.....

.....

.....

(ii)

.....

.....

[2]

.....

(d) Describe and explain what happens to the copper(II) nitrate solution during electrolysis.

.....

.....

[2]

.....

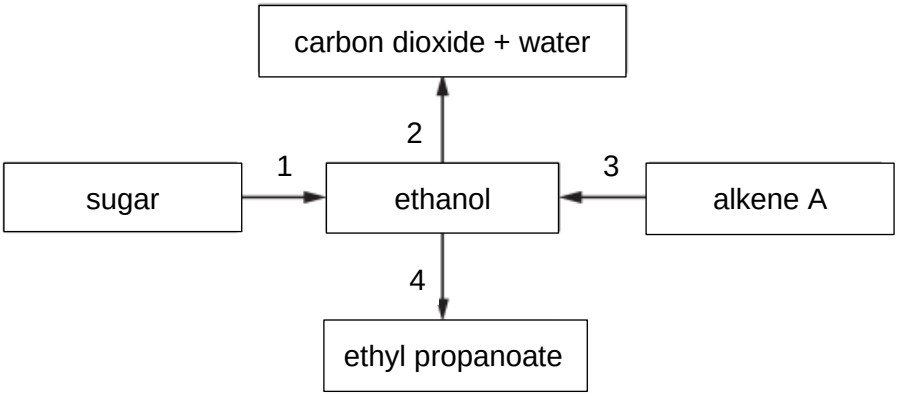
(e) Calculate the number of atoms of copper produced when copper(II) nitrate solution is electrolysed for 20 minutes at a current of 0.6 A.

[2]

OR

B10 This question is on organic chemistry.

(a) The reaction scheme shows four organic reactions, numbered 1 to 4.



(i) Compare Reactions 1, 2 and 3 in terms of names of reactions, reaction conditions and products of reaction.

You may present your answer in a table.

[4]

(ii) Draw the full structural formula of ethyl propanoate.

[1]

(b) Alcohols are oxidised by acidified potassium manganate (VII) to form carboxylic acid.

Carboxylic acids belong to a homologous series.

The table shows information about the first three carboxylic acids in this homologous series.

Name	Formula	pH of 0.01 mol/dm^3 solution
Methanoic acid		2.91
Ethanoic acid	CH_3COOH	3.39
Propanoic acid	CH_3CH_2COOH	3.44

(i) Draw a 'dot-and-cross' diagram of methanoic acid.

Show only the outer shell electrons.

[2]

(ii) The student compares the rate of reaction of zinc carbonate with two acids, 0.01 mol/dm^3 of methanoic acid and 0.01 mol/dm^3 of propanoic acid.

Using the information given, explain why the rate of reaction of zinc carbonate with methanoic acid is different from that with propanoic acid.

.....

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.....

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.....

.....

[3]

END OF PAPER

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		**Key** proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 A*l* aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 C*l* chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 T*l* thallium 204	82 Pb lead 207	83 Bi bismuth 209	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 F*l* flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	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 –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Answers for 2023 Prelim Section A

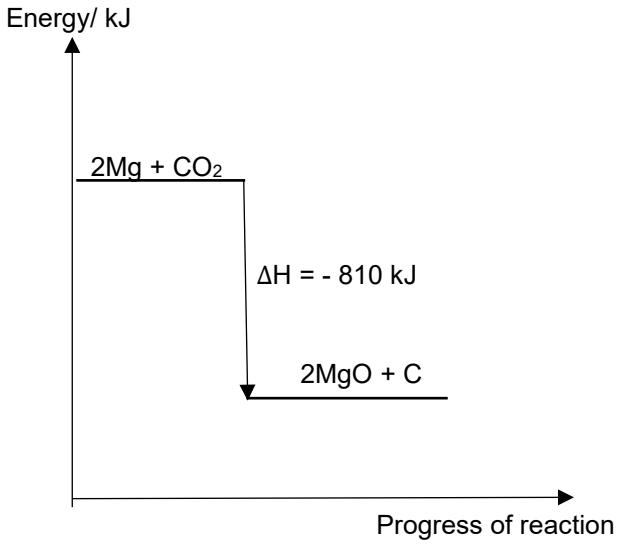
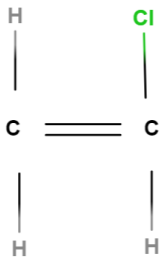
A1	(a)	Ammonium chloride		1
	(b)	Butene		1
	(c)	Methane		1
	(d)	Phosphorus oxide/ sulfur dioxide/ ammonium chloride		1
	(e)	Argon		1
A2	(a)	% of Fe in Fe_2O_3 = 122/160 x 100% = 70.0% % of Fe in Fe_3O_4 = 168/232 x 100% = 72.4% % of Fe in $FeCO_3$ = 56/116 x 100% = 48.3% Highest percentage of Fe is in Fe_3O_4/ magnetite		1 1 1
	(b)	(i)	$Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$	1
		(ii)	Iron ions/ iron(II) ions/ iron(III) ions in magnetite gained electrons to form iron atoms	1
	(c)	Metals have positive ions held in fixed positions Layers of ions can slide around one another		1 1
A3	(a)	A – aluminium chloride/ zinc chloride B - iron(III) carbonate D – silver chloride E – iron(III) sulfate		1 1 1 1
	(b)	$Al^{3+} + 3OH^- \rightarrow Al(OH)_3$ Or $Zn^{2+} + 2OH^- \rightarrow Zn(OH)_2$		1
	(c)	Test for the gas by bubbling it into limewater If white precipitate forms in limewater, gas is carbon dioxide.		1 1
	(d)	B has a giant ionic structure. F has a simple molecular structure. Strong ionic bonds between oppositely charged ions in B. Weak intermolecular forces of attraction in F. Large amount of energy taken in to break bonds in B. Small amount of energy taken in to overcome forces in F (can also have various combinations but no half marks)		1 1 1

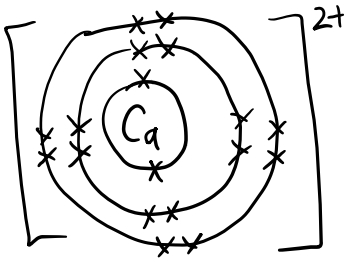
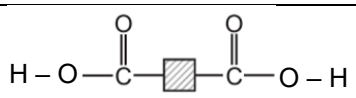
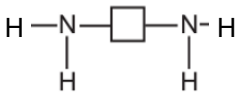
<table>
<tr><td>A4</td><td>(a)</td><td>(i)</td><td>No. of moles of I_2 = 0.508/(2 x 127) = 0.002
No. of moles of O_2 = 0.002/2 = 0.001
Concentration of O_2 = 0.001/2 = 0.0005 mol/dm^3</td><td>1

1</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>~~Volume of O_2 = 0.001 x 24 = 0.024 dm^3~~ Mass of O_2 = 0.001 x 32 = 0.0032g</td><td>1</td></tr>
<tr><td></td><td>(b)</td><td colspan="2">More oxygen molecules per unit volume
Higher frequency of effective collisions, hence faster rate of reaction</td><td>1
1</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>A5</td><td>(a)</td><td colspan="2">Full valence shell/ outermost shell, stable and thus no tendency to lose, gain or share electrons</td><td>1</td></tr>
<tr><td></td><td>(b)</td><td colspan="2"><table><tr><th>isotope</th><th>number of protons</th><th>number of electrons</th><th>number of neutrons</th></tr><tr><td>$^{36}_{18}Ar$</td><td>18</td><td>18</td><td>18</td></tr><tr><td>$^{40}_{18}Ar$</td><td>18</td><td>18</td><td>22</td></tr></table></td><td>1

1</td></tr>
<tr><td></td><td>(c)</td><td colspan="2">Elements in the Periodic Table are arranged in order of number of protons/ atomic number
Calcium atom has two protons more than argon atom (no marks)</td><td>1</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>A6</td><td>(a)</td><td colspan="2">Any of the following:
- Solid carbon dioxide block sublimes/ shrinks
- Hole in block gets deeper/bigger
- Black/ grey/ white solid/ powder/ fume/ smoke formed</td><td>1</td></tr>
<tr><td></td><td>(b)</td><td colspan="2">Low temperature of solid carbon dioxide/
Heat absorbed to sublime carbon dioxide.</td><td>1</td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>No. of moles of Mg = 2/24 = 0.083333
2 mol of Mg gives off 810 kJ of heat
Therefore 2 g of Mg gives off 405 x 0.083333 = 33.75 kJ = 33.8kJ</td><td>1

1</td></tr>
</table>

A6	(c)	(ii)	 1m – correctly drawn2 energy lines joined by an arrow pointing downward. 1m for labels	2
	(c)	(iii)	Less energy taken in to break bonds in magnesium and carbon dioxide than Energy given out to form bonds in magnesium oxide and carbon	1 1
	(d)	No, as magnesium is more reactive than carbon and carbon cannot reduce magnesium oxide Or magnesium is reactive and magnesium oxide is a stable compound. carbon cannot reduce magnesium oxide Or The activation energy of the reverse reaction is much higher than that of the forward reaction.		1
A7	(a)			1

A7	(b)	(i)	Calcium chloride, $CaCl_2$	1
		(ii)		1
		(iii)	Mix aqueous calcium chloride/ nitrate with aqueous sodium carbonate. Filter to obtain the residue of calcium carbonate. Rinse with deionised/ distilled water and dry calcium carbonate between sheets of filter paper.	1 1 1
	(c)		**1 molecule is $\frac{1}{6 \times 10^{23}}$ mole** **Empirical formula for poly(ethene) = CH_2** **$M_r = (CH_2)_n$** **Each single molecule contains 2000 to 20 000 carbon atoms** **$C_{2000}H_{4000}$ to $C_{20\,000}H_{40\,000}$** $\frac{1}{6 \times 10^{23}} = \frac{\text{mass of 1 molecule}}{2000 \times 12 + 4000 \times 1}$ **mass of 1 molecule = $\frac{2000 \times 12 + 4000 \times 1}{6 \times 10^{23}}$ = 4.67×10^{-20} g** **mass of 1 molecule = $\frac{20\,000 \times 12 + 40\,000 \times 1}{6 \times 10^{23}}$ = 4.67×10^{-19} g** **Mass range : 4.67×10^{-20} g to 4.67×10^{-19} g**	1 1
	(d)		 	1 1

2023 Section B Prelim ('O' level Track)

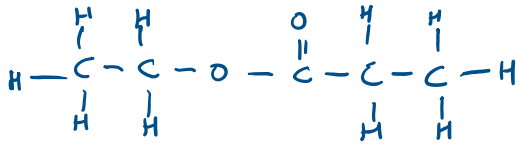
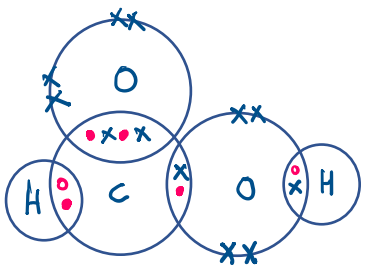
B8	(a)	(i)	Sulfur dioxide reacts/combines with oxygen and water/moisture to form sulfuric acid. Sulfuric acid dissolves in rainwater to form acid rain	[1] [1]
		(ii)	$2BaCO_3 + 2SO_2 + O_2 \rightarrow 2BaSO_4 + 2CO_2$	[1]
		(iii)	Barium sulfate formed is the least soluble in water; And the reaction removes sulfur dioxide thus less sulfuric acid/reduces the formation of acid rain.	[1] [1]
	(b)	(i)	In blue hydrogen, no carbon dioxide is released into the environment / the carbon dioxide captured and stored can be used to make synthetic fuels. In grey hydrogen, the carbon dioxide produced and released can <u>lead to global warming.</u>	[1] [1]
		(ii)	For Fuel Cell, only water is produced which is a non-pollutant/ no carbon dioxide is produced in this set-up or in Fuel Cell. Solar energy is renewable.	[1] [1]
		(iii)	The movement of electrons from the hydrogen end to the oxygen end produces electricity.	[1]
		(iv)	For Fuel cell, the refuelling time in minutes is <u>a lot shorter</u> than the charging time for electric car. This leads to commuters <u>saving time</u>. The mass of car using fuel cell is lighter so the car can travel faster or further with the same amount of energy. Reject: easier to drive, less energy is needed to power the car.	[1] [1]

B9	(a)	Chlorine atom has an unpaired valence electron or odd number of valence electron		[1]
	(b)	The oxidation state of chlorine decreases from +5 in $HClO_3$ to +4 in ClO_2. Hence, chlorine in $HClO_3$ is reduced. The oxidation state of chlorine increases from +5 in $HClO_3$ to +7 in $HClO_4$. Hence, chlorine in $HClO_3$ is oxidised. Since both oxidation and reduction takes place, it is a Redox reaction.		[1] [1]
	(c)	(i)	$2NaClO_3 + (COOH)_2 + H_2SO_4 \rightarrow Na_2SO_4 + 2ClO_2 + 2CO_2 + 2H_2O$	[1]
		(ii)	Both ionic and covalent bonding	[1]

		(iii)	$(COOH)_2(aq) + 2NaOH(aq) \rightarrow (COONa)_2(aq) + 2H_2O(l)$ M =? M= 0.100 V= 25.0 V= 14.0 $\frac{M\ X\ 25}{0.1\ X\ 14} = \frac{1}{2}$ (method mark) M = 0.028 mol/dm^3 Mass of pure hydrated oxalic acid = 0.028 × 2(12 +16 × 2 +1) + 2(18) [M] = 0.028 ×126 = 3.528 g % purity of hydrated oxalic acid = $\frac{3.528}{5.00}$ X 100% = 70.6 %	[1] [1] [1]
Either				
B10	(a)	$Cu^{2+} + 2e \rightarrow Cu$		[1]
	(b)	Filter the mixture; Rinse the copper with water and allow to dry Weigh the pure, dry copper using an electronic weighing balance Add the mass of this pure dry copper to the mass of the increase of copper at the negative electrode to obtain the total mass of the copper produced. Or find the gain in mass of copper at the negative electrode and add it to the mass of pure, dry copper obtained after filtration.		[1] [1] [1]
	(c)	(i) Yes, I agree. Keeping the current constant e.g at 0.3A, when time is doubled (from 10 mins to 20 min), total mass of copper produced is doubled (0.06g to 0.12g) (ii) Yes, I agree. Keeping time constant e.g. 20 minutes, when current is doubled (from 0.3 A to 0.6 A), the total mass of copper produced is double (0.12 g to 0.24 g)		[1] [1]
	(d)	2 answers: The solution becomes acidic; Copper(II) ions are selectively discharged at the cathode while hydroxide ions are discharged at the anode leaving behind nitric acid. Or the solution becomes acidic; concentration of hydrogen ions are higher than hydroxide ions.		[1] [1] [1] [1]

		Or The blue electrolyte fades/colourless. This is because copper(II) ions which gives the blue colour of the electrolyte are selectively discharged at the cathode while at the anode hydroxide ions are selectively discharged.	[1] [1]
	(e)	Mass of copper = 0.24 (from the graph) No. of moles of copper = $\frac{0.24}{64}$ = 0.00375 No. of copper atoms = 0.00375 x 6 x 10^{23} = 2.25x 10^{21}	[1] [1]

Or

B10	(a)	(i)	<table><tr><th>Reactions</th><th>Name of reaction</th><th>Reaction conditions</th><th>Products</th></tr><tr><td>1</td><td>Fermentation of sugar solution</td><td>Yeast, temperature 37°C, absence of oxygen(air)</td><td>ethanol + carbon dioxide</td></tr><tr><td>2</td><td>Combustion reaction</td><td>(Excess) oxygen, heat</td><td>carbon dioxide + water</td></tr><tr><td>3</td><td>Addition of steam/ Addition reaction/Hydration</td><td>Steam, 300°C, 65 atm, phosphoric acid as catalyst</td><td>ethanol</td></tr></table> Each row [1] Comparison of products [1] Comparison of products : Reaction 1and 2 has 2 products while reaction 1 has only one product/carbon dioxide is produced in reaction 1 and 2/ Ethanol is produced in reaction 1 and 3.	[4]
		(ii)		[1]
	(b)	(i)	HCOOH 	[2]

		(ii)	pH of methanoic acid is lower than propanoic acid therefore Concentration of hydrogen ions in methanoic acid is higher than propanoic acid/ no. of hydrogen ions per unit volume is higher There is higher frequency of effective collision between particles leading to faster rate of reaction.	[1] [1] [1]