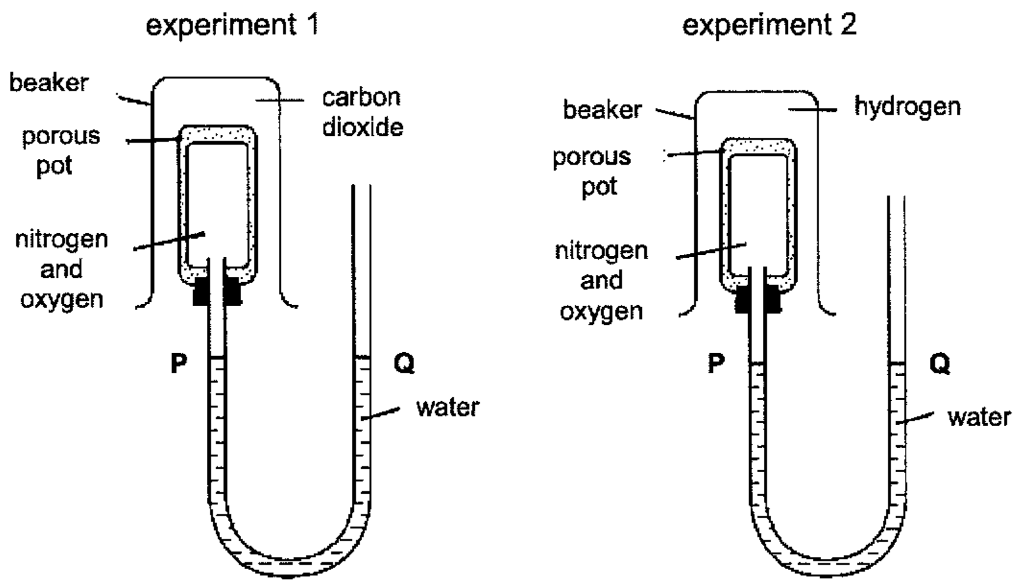
1 Two experimental set-ups used to demonstrate diffusion of gases are shown in the diagrams below. Each porous pot contains a mixture of nitrogen and oxygen.



What changes, if any, to the water levels **P** and **Q**, would you expect to see in both experiments?

	experiment 1	experiment 2
A	**P** and **Q** remain the same	**P** and **Q** remain the same
B	**P** and **Q** remain the same	**Q** is higher than **P**
C	**P** is higher than **Q**	**Q** is higher than **P**
D	**Q** is higher than **P**	**Q** is higher than **P**

2 Which piece of apparatus could be used to determine the end-point of the reaction between hydrochloric acid and potassium hydroxide?

A electronic balance
B gas syringe
C stopwatch
D thermometer

3 A new substance was discovered and a series of experiments were conducted on it.

Which observation suggests that the substance **cannot** be an element?

A It has a fixed boiling point.
B It dissolves in water to form a yellow-green solution.
C When heated strongly, a brown solid and a yellow gas are produced.
D When heated in air, it can form oxides with two different chemical formulae.

4 Three atoms are shown.

$$^{32}_{16}X \qquad ^{33}_{16}Y \qquad ^{32}_{17}Z$$

What can be deduced from the proton numbers and nucleon numbers of X, Y and Z?

A X and Y are the same element.
B X and Z are the same element.
C Y has more protons than X.
D Z has more neutrons than Y.

5 Which element has the most number of electrons in the outermost shell of its atoms?

A argon
B boron
C chlorine
D potassium

6 What are isotopes?

A Atoms of different elements with the same nucleon number but different proton number.
B Atoms of the same element with the same nucleon number but different proton number.
C Atoms of the same element with the same number of protons but different numbers of neutrons.
D Atoms of the same element with the same number of neutrons but different numbers of protons.

7 Which of the following substances contains both ionic and covalent bonds?

A aluminium carbonate
B graphite
C hydrogen chloride
D sodium

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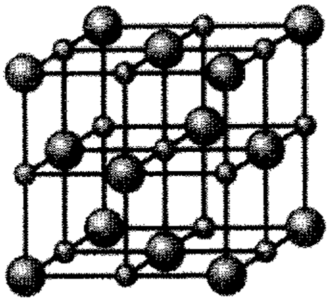
8 The diagram shows the arrangement of the ions in an ionic lattice.



Which compound would likely have this arrangement?

A barium fluoride
B lithium nitride
C magnesium hydroxide
D sodium chloride

9 Which ionic equation represents the reaction when calcium carbonate powder is added to hydrochloric acid?

A $H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$
B $Ca^{2+} (aq) + 2Cl^- (aq) \rightarrow CaCl_2 (s)$
C $2H^+ (aq) + CO_3^{2-} (aq) \rightarrow CO_2 (g) + H_2O (l)$
D $CaCO_3 (s) + 2H^+ (aq) \rightarrow Ca^{2+} (aq) + CO_2 (g) + H_2O (l)$

10 Bones contain a complex mixture of calcium salts, protein and other materials. When a bone is strongly heated in a current of air, the only residue is calcium oxide. From a sample of 100 g of bone, 42.0 g of calcium oxide were obtained.

What is the percentage by mass of calcium in the bone?

A 12.0 % **B** 30.0 % **C** 42.0 % **D** 71.4 %

11 Which of the following statements does **not** describe a property of a weak alkali?

A It has a pH between 8 to 10.
B It forms a salt with sodium metal.
C It is only partially dissociated into ions.
D It turns universal indicator solution blue.

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12 Which chemical is best used to distinguish between calcium chloride and calcium carbonate?

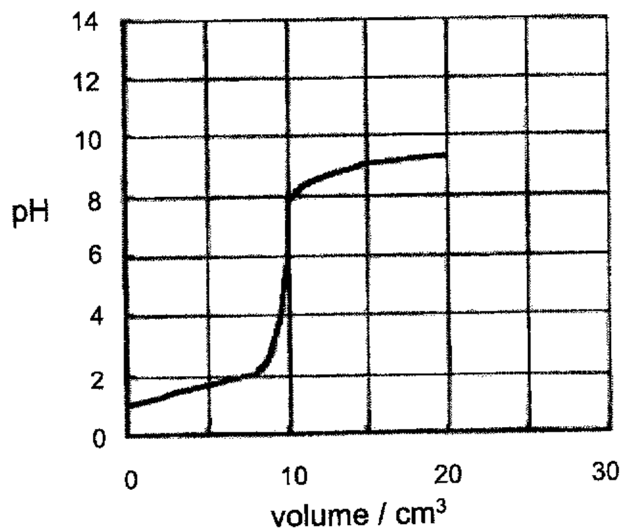
A aqueous sodium hydroxide
B dilute hydrochloric acid
C silver nitrate solution
D universal indicator solution

13 Which of the following is **not** a common use of sulfuric acid?

A battery acid
B making of wooden furniture
C manufacture of detergent
D manufacture of fertilliser

14 In an acid-base titration, a 0.10 mol/dm^3 alkali is added to 10 cm^3 of 0.10 mol/dm^3 dilute acid.

The graph below shows the change in pH during the titration.



Which of the following represents the titration shown in the graph?

A ethanoic acid and aqueous sodium hydroxide
B ethanoic acid and aqueous ammonia
C nitric acid and aqueous sodium hydroxide
D nitric acid and aqueous ammonia

15 In which equation does the metal oxide act as an acidic oxide?

A $K_2O\ (s) + H_2O\ (l) \rightarrow 2KOH\ (aq)$
B $Fe_2O_3\ (g) + 3CO\ (g) \rightarrow 2Fe\ (s) + 3CO_2\ (g)$
C $Al_2O_3\ (s) + 6HCl\ (aq) \rightarrow 2AlCl_3\ (aq) + 3H_2O\ (l)$
D $PbO\ (s) + H_2O\ (l) + OH^-\ (aq) \rightarrow Pb(OH)_3^-\ (aq)$

16 A colourless solution contains two cations. When aqueous ammonia was added to the solution, a white precipitate was formed. When excess aqueous ammonia was added, the white precipitate dissolved to form a colourless solution.

Which of the following is **not** a possible cation in the solution?

A Ca^{2+}
B K^+
C Pb^{2+}
D Zn^{2+}

17 Zinc sulfate was prepared by reacting sulfuric acid with excess zinc oxide. What is the sequence of steps that needs to be carried out to collect the pure and dry salt after the above reaction?

A crystallisation → filtration
B distillation → crystallisation
C filtration → evaporate to dryness
D filtration → air dry

18 Nitrogen dioxide reacts with water according to the following equation

$$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$$

Which of the following statements correctly describes this reaction?

A NO_2 is reduced to form HNO_3.
B The oxidation state of N in HNO_2 is +3.
C The reaction is a decomposition reaction.
D Water acts as a catalyst in this reaction.

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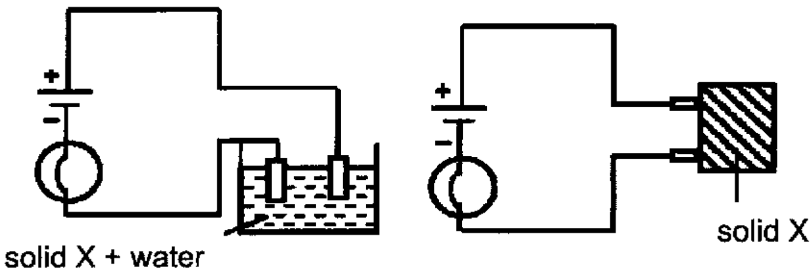
19 Which of the following reactions that takes place in the blast furnace is an acid-base reaction?

A $C + O_2 \rightarrow CO_2$
B $CO_2 + C \rightarrow 2CO$
C $CaO + SiO_2 \rightarrow CaSiO_3$
D $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

20 Two circuits are shown below. The light bulb lights up in only one of the circuits.



What is the identity of X?

A barium sulfate　　**B** magnesium
C potassium bromide　　**D** sugar

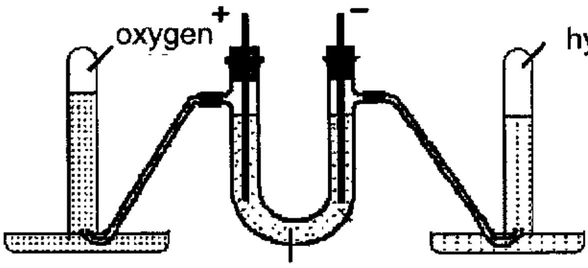
21 In which electrolysis experiment would there be **no** change in pH of the solution when inert electrodes are used?

A aqueous copper (II) nitrate
B aqueous silver sulfate
C concentrated copper (II) chloride solution
D concentrated potassium bromide solution

22 When aqueous copper (II) sulfate is electrolysed using copper electrodes, which observations are correct?

	positive electrode	negative electrode	intensity of blue colour of electrolyte
A	electrode becomes smaller	electrode becomes bigger	constant
B	electrode becomes smaller	gas given off	fades
C	gas given off	electrode becomes bigger	fades
D	gas given off	gas given off	constant

23 The diagram shows the electrolysis of dilute sodium chloride solution using inert electrodes.



Given that, at room temperature and pressure, x moles of electrons were passed in the circuit, which of the following statement is correct?

A $6x$ dm^3 of oxygen was collected at the anode.
B $6x$ dm^3 of hydrogen was collected at the cathode.
C $12x$ dm^3 of oxygen was collected at the cathode.
D $12x$ dm^3 of hydrogen was collected at the anode.

24 Which of the following properties generally decreases when going across a period of the Periodic Table from Group I to Group VII?

A The acidity of the oxides.
B The oxidizing ability of the elements.
C The number of electrons in the valence shell.
D The tendency of the elements to form positive ions.

25 Elements X, Y and Z are in the same period of the Periodic Table.

Solid X conducts electricity.
Oxides of Y reacts with both acid and alkali.
Oxides of Z dissolves in water to form solution with pH < 7.

In which order do the elements appear in the Periodic Table?

A X → Y → Z
B Y → X → Z
C Z → X → Y
D Z → Y → X

26 In the Haber Process, nitrogen and hydrogen react to form ammonia. The following are some statements about the process:

I The reaction uses a transition metal as catalyst.
II Hydrogen is obtained from the fractional distillation of air.
III The temperature used is typically between 400 °C to 500 °C.

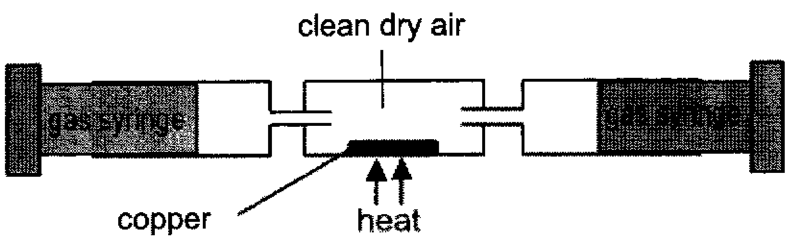
Which of the statements are correct?

A I and II only **B** II and III only **C** I and III only **D** I, II and III

27 Which of the following reactants will **not** produce ammonia on heating?

A ammonium chloride and lithium oxide
B ammonium sulfate and hydrochloric acid
C ammonium nitrate and potassium hydroxide
D ammonium phosphate and calcium hydroxide

28 A sample of clean, dry air is passed over hot copper until all the oxygen in the air reacts with the copper. The volume of air decreases by 60 cm^3.



What is the initial volume of the sample of air?

A 75 cm^3 **B** 120 cm^3
C 300 cm^3 **D** 600 cm^3

29 Carbon monoxide is a pollutant emitted from car exhausts. Which of its properties makes it harmful to humans?

A It combines with oxygen in the lungs.
B It forms a stable compound with blood.
C It has a corrosive action on lung tissue.
D It is odourless, colourless and tasteless.

30 Which process removes carbon dioxide from the atmosphere?

A combustion of carbon-containing fuel
B flue gas desulfurisation
C photosynthesis
D respiration

31 The table shows the boiling points of four fractions when crude oil is distilled.

fraction	W	X	Y	Z
boiling point / °C	35 – 75	80 – 145	150 – 250	greater than 250

Which statement regarding the fractions is true?

A Fraction Y is less flammable than fraction W.
B Fraction Y is less viscous than fraction X.
C The molecular mass of fraction Z is smaller than that of fraction X.
D The molecules in Z have a shorter chain length than those in fraction Y.

32 Which statement correctly describes the members of a homologous series?

A They have the same empirical formula.
B They have the same physical properties.
C They undergo similar chemical reactions.
D The relative molecular masses of consecutive members differ by 12.

33 Which statement about vegetable oil and the margarine made from it is correct?

A Both occur naturally.
B Margarine has the higher melting point.
C Both are liquids at room temperature and pressure.
D Vegetable oil has fewer carbon-carbon double bonds than margarine.

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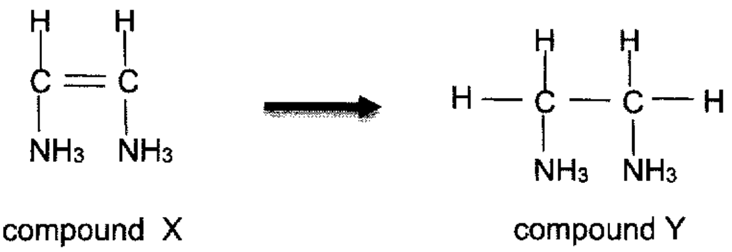
34 The following compound X can be converted into the following compound Y.



Which of the following correctly shows the reagents and conditions needed for the conversion?

	reagent	conditions
A	hydrogen	200 °C, nickel catalyst
B	concentrated sulfuric acid	heat
C	steam	300 °C, 60 atm, phosphoric acid
D	monomer	450 °C, iron catalyst

35 Which of the following could **not** be produced when methane reacts with fluorine in the presence of ultraviolet light?

A fluoromethane
B hydrogen
C hydrogen fluoride
D tetrafluoromethane

36 When tetradecane, $C_{14}H_{30}$, is cracked, only three hydrocarbons are formed. The hydrocarbons are ethene, propane and propene.

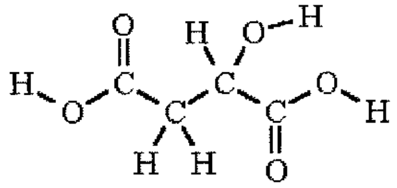
What is the ratio of the hydrocarbons formed?

	ethene	propane	propene
A	1	1	1
B	1	2	2
C	1	3	1
D	4	1	1

37 Terylene and nylon are man-made fibres. Which of the following is **not** a typical use of such fibres?

A clothing
B fishing line
C food product
D parachute

38 Apples contain malic acid. The diagram below shows the structural formula of malic acid.

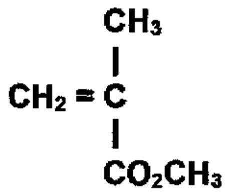


Which of the following salt(s) could be formed upon reacting malic acid with sodium hydroxide?

I $C_4H_5O_5Na$
II $C_4H_4O_5Na_2$
III $C_4H_3O_5Na_3$

A II only
B I and II only
C II and III only
D I, II and III

39 Bone cement, used in artificial hip and knee replacements, is formed by the polymerisation of methyl methacrylate and the process is highly exothermic.

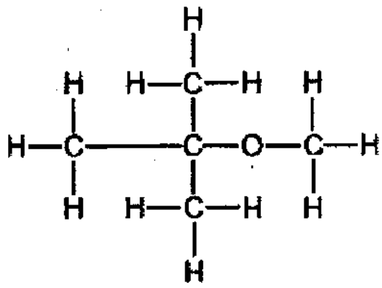


methyl methacrylate

Which statement about bone cement is true?

A The empirical formula of bone cement is $C_5H_8O_2$.
B Aqueous bromine is decolourised by bone cement.
C Water is formed in the polymerisation of methyl methacrylate.
D Less energy is released in the formation of C-C bond than the energy absorbed in the breaking of C=C bond.

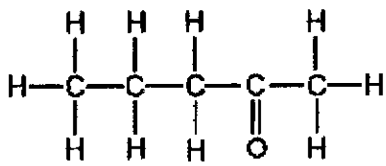
40 The structural formula of compound Z is shown.



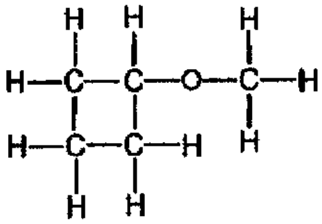
compound Z

Which of the following compound is an isomer of compound Z?

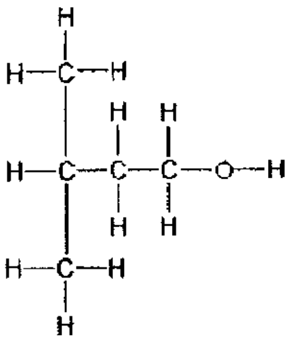
A



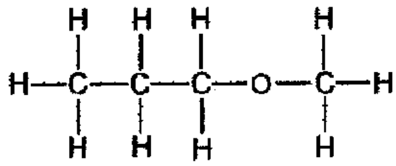
B



C



D



END OF PAPER

Section A

Answer all questions.

1 The table shows some information about substances A to E.

substance	melting point / °C	boiling point / °C	Does it conduct electricity when it is a solid?	Does it conduct electricity when molten?
A	–71	–62	no	no
B	–8	58	no	no
C	1240	2100	yes	yes
D	1473	1700	no	yes
E	1649	2231	no	no

(a) Which substance is most likely to be tungsten(VI) oxide?

.... [1]

(b) Which substance is most likely to be argon?

.... [1]

(c) Which substance is most likely to be used as a cutting tool?

.... [1]

(d) Draw the heating curve of substance B when the temperature increased from –20 °C to 50 °C.

[2]

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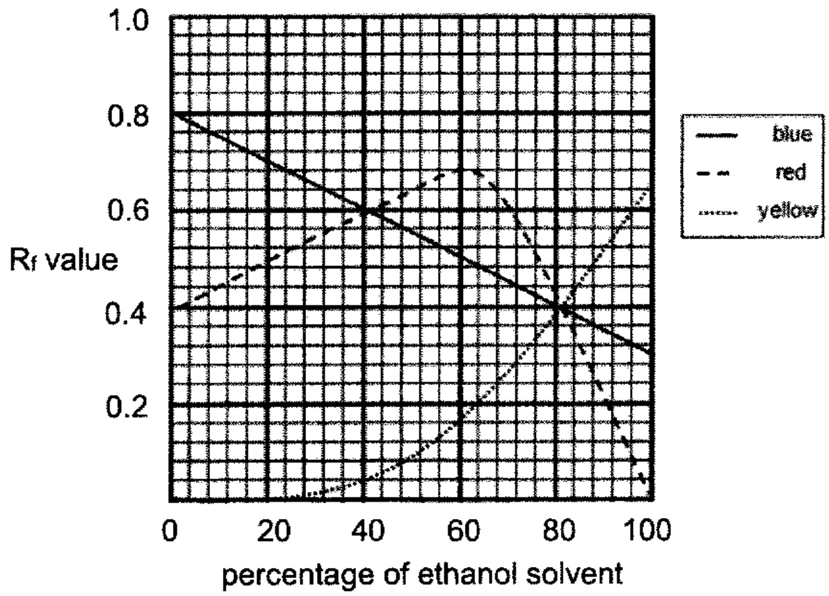
2 A sample of ink contains a mixture of red, blue and yellow dyes. To separate the dyes in the ink, the solvent used is a mixture of water and ethanol. The R_f values of the coloured dyes in solvents with different percentage of ethanol present are shown.



(a) What is the R_f value of the blue dye when a solvent mixture containing 90 cm^3 ethanol and 60 cm^3 water is used in the chromatography?

R_f value of the blue dye: .... [1]

(b) A mixture of water and ethanol was used to separate a sample of this ink. Only one spot was formed on the chromatogram. Using evidence from the graph, explain why it **cannot** be concluded that the ink sample is a pure substance.

....

....

.... [2]

(c) Suggest a suitable method to separate the water and ethanol solvent mixture.

.... [1]

3 The world is trying to reduce the reliance of fossil fuel by exploring alternative fuels. The table below gives some information about the different fuels explored.

fuel	physical state at room temperature and pressure	enthalpy change of combustion / kJ / mol	products of complete combustion
hydrogen	gas	- 256	H_2O only
methanol	liquid	- 715	CO_2 and H_2O
methane	gas	- 890	CO_2 and H_2O

(a) The complete combustion of methane is represented by the following equation.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

(i) Calculate the mass of methane that needs to be combusted to produce 3115 kJ of heat.

[1]

(ii) Using ideas about breaking and forming bonds, explain why the enthalpy change for the complete combustion of methane has a negative sign.

....

....

.... [2]

(b) Using only information from the table, state one advantage and one disadvantage of using methanol as a fuel compared to hydrogen apart from the amount of heat given out.

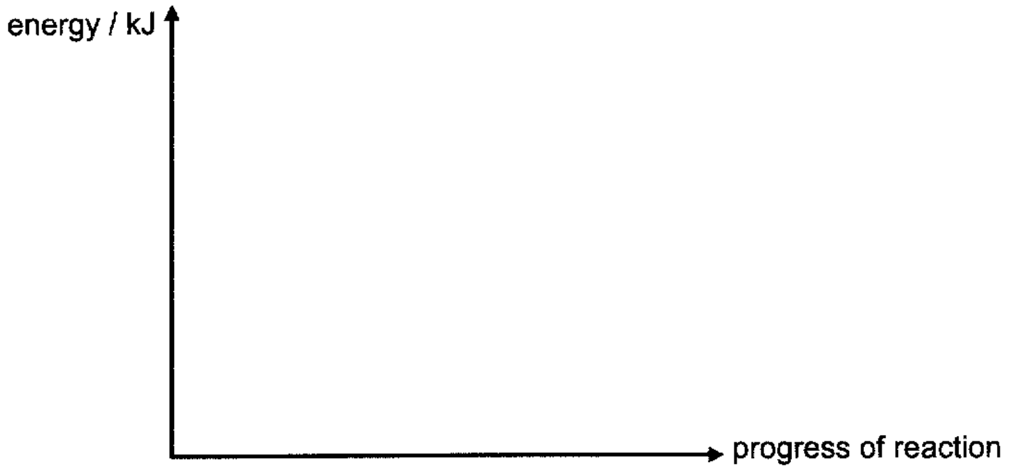
advantage: ....

....

disadvantage: ....

.... [2]

(c) Draw an energy profile diagram for the complete combustion of hydrogen. Indicate the enthalpy change, ΔH and activation energy, E_a on the diagram clearly.



[3]

4 Duralumin is a mixture of aluminium with copper. It is used mainly in machine parts due to its high strength and hardness compared to aluminium. However, duralumin is more susceptible to corrosion than aluminium.

(a) State the name given to mixtures such as duralumin.

.... [1]

(b) Explain why duralumin is harder than aluminium.

....

.... [2]

(c) Explain why duralumin corrodes more easily than aluminium.

....

.... [2]

(d) Recycling of metals has been encouraged as a way to produce useful metals instead of extracting them from their ores. Explain why.

....

.... [1]

5 Acidified potassium manganate(VII) reacts with excess sodium ethanedioate. The ionic equation of the reaction is shown below.

$$2\ MnO_4^- (aq) + 16\ H^+ (aq) + 5\ C_2O_4^{2-} (aq) \rightarrow 2\ Mn^{2+} (aq) + 8\ H_2O\ (l) + 10\ CO_2\ (g)$$

(a) Describe two observations in this experiment.

....

.... [2]

(b) State and explain, in terms of oxidation state, which chemical species is the reducing agent.

....

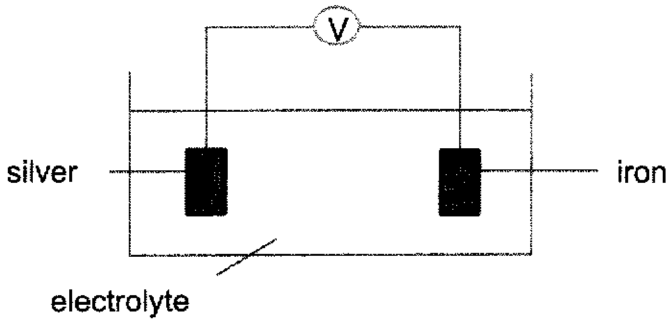
....

.... [2]

(c) Calculate the volume of CO_2 produced at r.t.p given that 25.0 cm^3 of 0.5 mol/dm^3 of potassium manganate(VII) was used.

[3]

6 The diagram shows a simple cell set-up.



Complete the table by filling in the missing information.

electrolyte used	electrodes used	product formed at positive electrode	product formed at negative electrode
aqueous sodium nitrate	silver and iron		
	silver and iron	silver	

[3]

7 A colorimeter measures the intensity of light that is absorbed by a coloured solution. The darker the colour of the solution, the more light is absorbed and the higher the reading on the colorimeter.

In experiment 1, fluorine gas was bubbled into aqueous potassium bromide for 6 minutes. The reaction mixture was measured with a colorimeter over time.

(a) Describe and explain how the colorimeter reading changes as the reaction takes place.

....

....

....

....

.... [3]

(b) In experiment 2, aqueous potassium bromide was replaced with aqueous potassium chloride of the same concentration.

(i) Draw a 'dot-and-cross' diagram to show the bonding in potassium chloride. Show only the valence electrons.

[2]

(ii) State one similarity and one difference in the experimental result between experiments 1 and 2.

Similarity: ....

....

Difference: ....

.... [2]

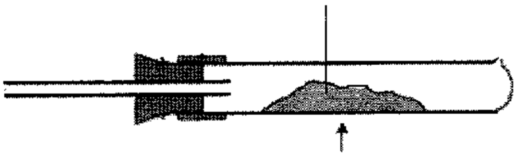
8 Hydrated copper(II) sulfate has the chemical formula, $CuSO_4 \cdot xH_2O$ where x can range from 0 to 5. The pentahydrate ($CuSO_4 \cdot 5H_2O$) is the most commonly encountered salt.

A sample of $CuSO_4 \cdot 5H_2O$ was heated over time to slowly remove the water of crystallisation. After some time it was noted that the mass of the sample decreased by 15% and $CuSO_4 \cdot 5H_2O$ was converted to compound P.

(a) Suggest the chemical formula for compound P.
Show your working clearly. [M_r $CuSO_4.5H_2O$ = 250]

chemical formula of compound P: .... [2]

(b) On further heating of the sample till 950 °C, it decomposed to form copper(II) oxide. Copper(II) oxide is then further heated with carbon in a glass tube to produce a gas and molten copper.



(i) Write an equation for the reaction between copper(II) oxide and carbon.

.... [1]

(ii) Molten copper(II) oxide and copper conduct electricity differently. Describe how they conduct electricity differently.

....

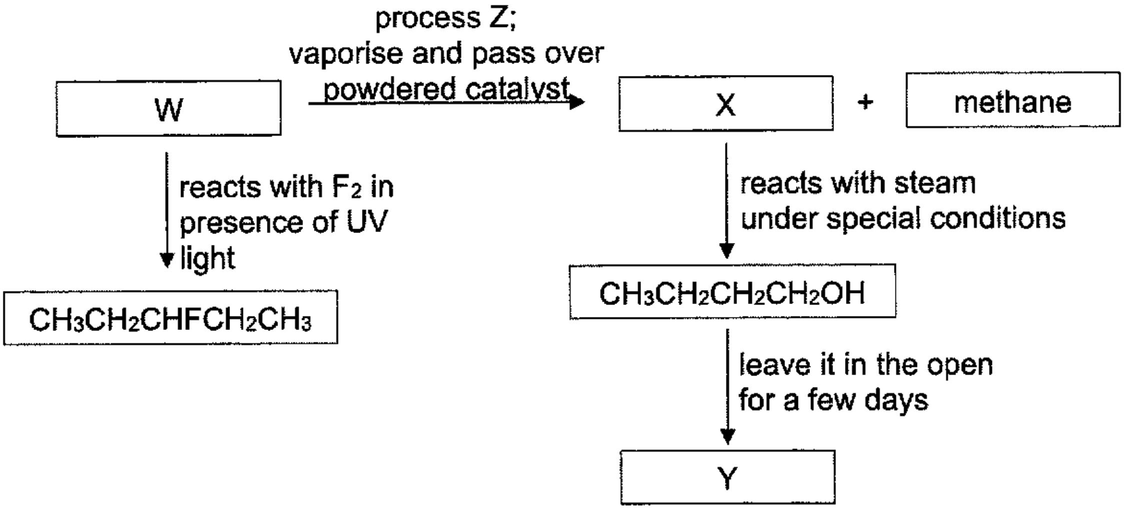
.... [1]

(iii) The conduction of electricity can have different effects on copper and on molten copper(II) oxide. Describe the difference.

....

.... [1]

9 The reaction of organic compound W is shown below.



(a) **(i)** Name the process Z.

.... [1]

(ii) Identify compound W.

.... [1]

(iii) Describe a chemical test to differentiate compound W from X.

....

....

.... [2]

(b) Suggest a way to determine if the reaction of $CH_3CH_2CH_2CH_2OH$ has been completely converted to Y.

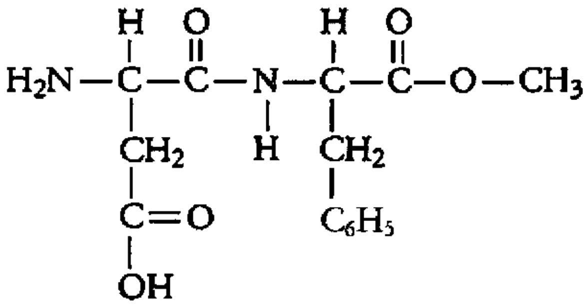
....

.... [1]

Section B

Answer all three questions in this section.
The last question is in the form **either/or** and only one of the alternative should be attempted.

10 The structural formula of the artificial sweetener, aspartame, is shown below.



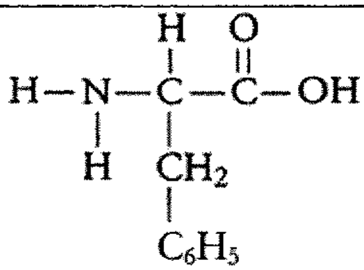
(a) Name two functional groups present in aspartame.

.... [1]

(b) Aspartame is hydrolysed in the stomach to produce methanol as well as the amino acids aspartic acid and phenylalanine.

Hydrolysis involves the reaction of an organic compound with water to form two or more new products through breakage of bonds in the organic compound.

Two of the products of hydrolysis of aspartame are shown below:

H—O—CH_3	
methanol	phenylalanine

(i) Draw the structural formula of aspartic acid.

[1]

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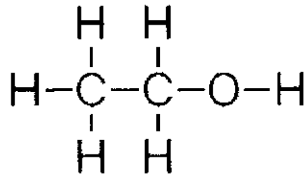
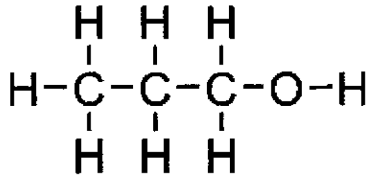
(ii) The full structural formulae of ethanol and propanol are shown below:

name of compound	full structural formula
ethanol	
propanol	

Explain why methanol, ethanol and propanol belong to the same homologous series.

....

....

.... [2]

(c) When warmed in the presence of concentrated sulfuric acid, methanol reacts with propanoic acid to form water and ester P.

(i) Name ester P.

.... [1]

(ii) Esters are commercially used in perfumes for its aromatic property.

State one other commercial use of ester.

.... [1]

(d) A macromolecule can be formed from phenylalanine undergoing condensation polymerisation as a single monomer.

(i) Define the term 'macromolecule'.

....

.... [1]

(ii) Draw the structural formula of the polymer formed from the monomer phenylalanine, showing two repeating units.

[1]

11 Reaction Rates

The reaction between colourless peroxodisulfate(VI) ions and iodide ions is represented by the following ionic equation.

$$S_2O_8^{2-}\,(aq) + 2I^-\,(aq) \rightarrow 2SO_4^{2-}\,(aq) + I_2\,(aq)$$

The same volume of aqueous $S_2O_8^{2-}$ and aqueous I^- are used for each experiment.

The table below shows the results of each experiment when different concentrations of each reactant are used.

experiment	initial concentration / mol/dm³		initial rate of reaction / mol/dm³s
	$S_2O_8^{2-}$	I^-	
1	0.008	0.020	1.22×10^{-3}
2	0.016	0.020	2.44×10^{-3}
3	0.032	0.020	4.88×10^{-3}
4	0.008	0.040	2.44×10^{-3}
5	0.008	0.080	4.88×10^{-3}

Order of Reactions

The order of a reaction refers to the power dependence of the rate of reaction on the concentration of each reactant. It is a numerical value.

In a zero-order reaction, the concentration of the reactants has no effect on the initial rate of reaction.
In a first-order reaction, the initial reaction rate is directly proportional to the concentration of one of the reactants.
In a second-order reaction, the initial rate of reaction quadruples when the concentration of one of the reactants is doubled.

Increasing the rate of reaction

If a small amount of Fe^{2+} ions is added to the reaction mixture, the rate of reaction will increase. Fe^{2+} will react with the peroxodisulfate(VI) ions, forming Fe^{3+} ions, which will then react with the iodide ions in the following two stages:

Stage 1: $2Fe^{2+}\,(aq) + S_2O_8^{2-}\,(aq) \rightarrow 2Fe^{3+}\,(aq) + 2SO_4^{2-}\,(aq)$

Stage 2: $2Fe^{3+}\,(aq) + 2I^-\,(aq) \rightarrow 2Fe^{2+}\,(aq) + I_2\,(aq)$

15

(a) **(i)** Suggest a method to measure the rate of reaction between peroxodisulfate(VI) ions and iodide ions.

.... [1]

(ii) Two students made comments about the reaction.

Student 1: The reaction is first order with respect to $S_2O_8^{2-}$.

Student 2: The reaction is second order with respect to I^-.

Which student is correct? Show by calculation using information from the table to support your answer.

....

....

....

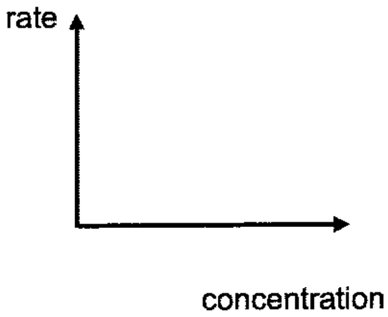
....

....

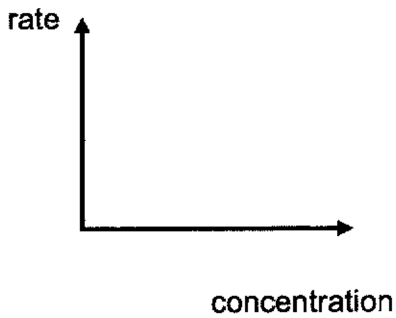
.... [3]

(iii) Sketch the graphs of rate against concentration of reactant for a zero-order and a first-order reaction.

zero-order reaction



first-order reaction



[2]

(iv) Another two similar experiments were carried out.

experiment	concentration of $S_2O_8^{2-}$ / mol/dm^3	concentration of I^- / mol/dm^3	initial rate of reaction / mol/dm^{3}s
6	0.016	0.040	
7		0.080	9.76×10^{-3}

Predict the initial rate of reaction in experiment 6 and the concentration of $S_2O_8^{2-}$ in experiment 7.

initial rate for experiment 6: ....

concentration of $S_2O_8^{2-}$ in experiment 7: .... [2]

(b) **(i)** Explain the role of Fe^{2+} ions when added into the reaction mixture.

....

.... [2]

(ii) Suggest a way to remove Fe^{2+} ions from aqueous iodine after Stage 2.

....

....

.... [2]

EITHER

12 Nickel is a transition element. It is manufactured in a four-stage process from nickel(II) sulfide, NiS.

Stage 1 – nickel(II) sulfide is heated in air to form nickel(II) oxide and sulfur dioxide
Stage 2 – nickel(II) oxide is heated with carbon to give impure nickel
Stage 3 – impure nickel is reacted with carbon monoxide to make nickel tetracarbonyl, $Ni(CO)_4$
Stage 4 – nickel tetracarbonyl is decomposed to give pure nickel

(a) **(i)** Construct the balanced equation for the reaction in stage 1.

.... [1]

(ii) Calculate the mass of sulfur dioxide that is formed when 182 kg of nickel(II) sulfide is heated in air.

[2]

(b) Explain why this 4-stage process **cannot** be used to manufacture magnesium.

....

....

.... [2]

(c) Nickel tetracarbonyl is a liquid with a boiling point of 43 °C.

Suggest, with a reason, the type of structure and bonding in nickel tetracarbonyl.

....

....

.... [2]

(d) In an experiment, small amounts of three metals were added to three aqueous metal nitrate solutions. The results are shown in the table.

	aqueous zinc nitrate	aqueous nickel(II) nitrate	aqueous copper(II) nitrate
zinc	no reaction	green solution turn colourless and zinc coated with a grey solid	blue solution turn colourless and zinc coated with a pink solid
nickel		no reaction	
copper	no reaction	no reaction	no reaction

Predict the observations when nickel is added to

(i) zinc nitrate solution

.... [1]

(ii) copper(II) nitrate solution

....

.... [2]

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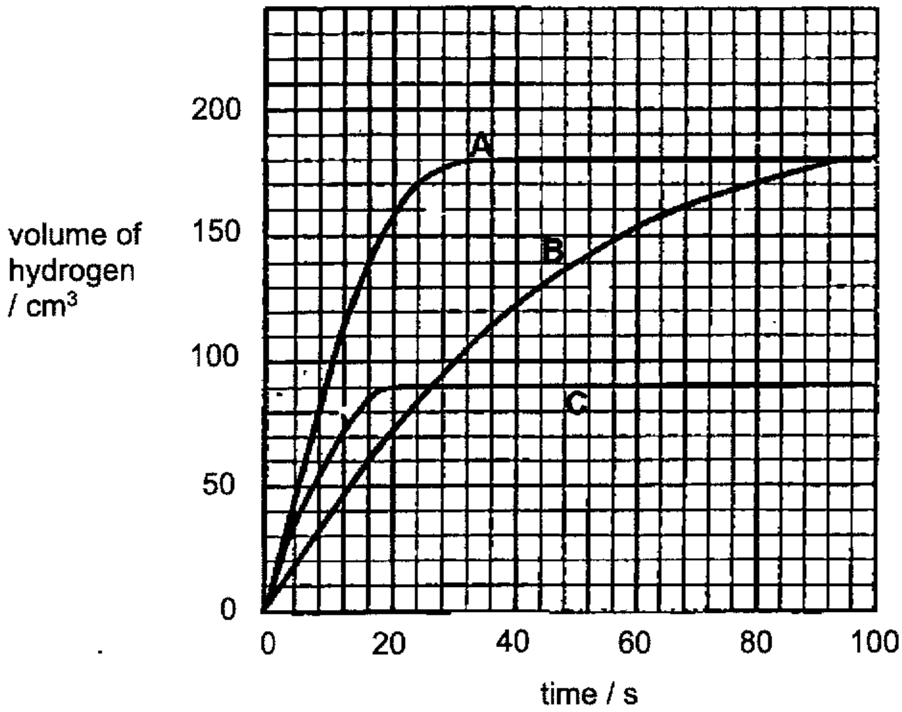
OR

12 In experiment 1, 0.488 g of zinc was reacted with two acids, hydrochloric acid and sulfuric acid separately. The volume and concentration of the acids used were both 20.0 cm^3 and 2.00 mol/dm^3. The curves A and B shown in the graph below show the results of the reactions.



In experiment 2, a similar reaction with an unknown mass of zinc and 20.0 cm^3 of a 2.00 mol/dm^3 acid was conducted. Curve C shows the result of the reaction.

(a) Explain, with relevant calculations, why the same volume of gas was produced for both curves A and B.

....

....

.... [3]

(b) Between curves A and B, identify the curve for the reaction that used sulfuric acid. Explain your choice.

....

....

.... [2]

(c) Given that either sulfuric acid or hydrochloric acid was used to obtain curve C,

(i) identify the acid used and state your reasoning.

.... [1]

(ii) calculate the mass of zinc used.

[1]

(d) Experiment 2 was repeated using the same mass of zinc and the same volume and concentration of the acid, but this time, a small amount of copper(II) sulfate crystals were added to the reaction mixture.

Effervescence was observed and a brown deposit was formed. The volume of hydrogen collected was slightly less than in experiment 2.

With the aid of an equation, explain why less hydrogen was collected.

....

....

....

....

.... [3]

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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 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 –		

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.).

END OF PAPER

Admiralty Secondary School
Marking Scheme
4E Pure Chemistry (Paper 1 and 2)
PRELIMINARY EXAMINATION 2021

PAPER 1 [40 marks]

1	2	3	4	5	6	7	8	9	10
C	D	C	A	A	C	A	D	D	B

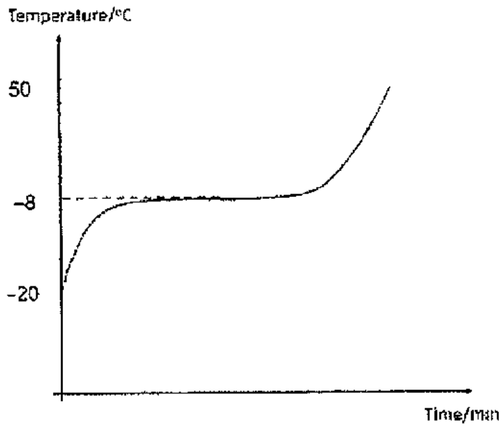
11	12	13	14	15	16	17	18	19	20
B	B	B	D	D	C	C	B	C	C

21	22	23	24	25	26	27	28	29	30
C	A	A	D	A	C	B	C	B	C

31	32	33	34	35	36	37	38	39	40
A	C	B	A	B	D	C	B	A	C

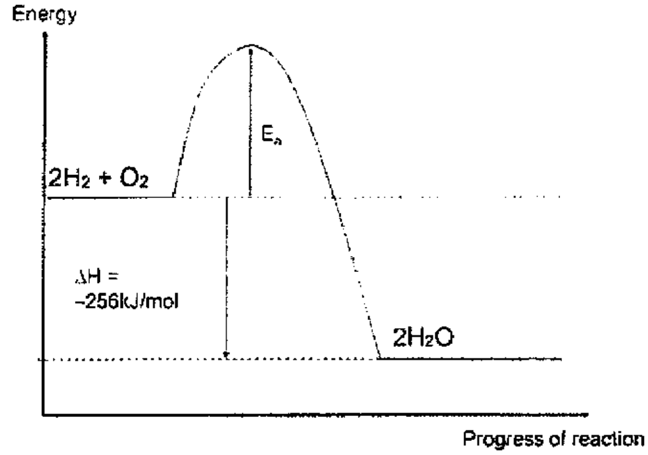
PAPER 2 SECTION A [50 marks]

Qn.	Description	Mark	Remarks
1a	D	1	
b	A	1	
c	E	1	

d	 1m: correct shape 1m: correct labelling of axes and values	2	

Qn.	Description	Mark	Remarks
2a	0.50	1	
b	The sample could be a mixture of three dyes if the solvent used is 80% ethanol. This is because only one spot will be observed as all three dyes have the same R_f value of 0.4	1 1	
c	Fractional distillation		A: simple distillation

Qn.	Description	Mark	Remarks
3ai	No of moles of methane = 3115/890 = 3.5 mol Mass of methane = 3.5 X 16 = 56g	1	
aii	The energy taken in to break 4 mol C-H bond and 2 mol O=O bond is less than the energy give out in the bond formation of 2 mol C=O bond and 4 mol O-H bond. Hence the reaction is exothermic and has a negative sign for enthalpy change.	2	1m: compare energy taken in and given out 1m: relate energy taken in to that of bond breaking of the reactants and energy given out as bond forming of products

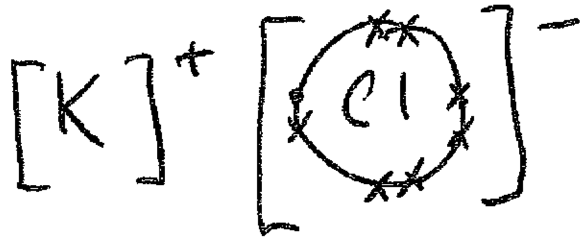
b	**Advantage**: Methanol is a liquid while hydrogen is a gas at rtp. <u>Easier to transport methanol</u> as transporting hydrogen would require use of pressurised tanks **Disadvantage**: Burning methanol releases carbon dioxide which is a greenhouse gas. While burning hydrogen produces only water which is non-pollutive	1 1	
c	 [1 mark for correct shape of graph, 1 mark for correct labelling of reactant and product, 1 mark for correct labelling of enthalpy change and activation energy]	3	

Qn.	Description	Mark	Remarks
4a	Alloy	1	
b	Aluminium consists of aluminiums atoms arranged in orderly layers. These layers can slide easily when a force is applied. While duralumin contains atoms of different sizes that disrupt the orderly arrangement of the atoms. Hence the atoms cannot slide over each other easily when a force is applied. Hence it is harder. 1m: describe correctly the arrangement of atoms in aluminium and duralumin. 1m: describe correctly the ease of atoms sliding over each other when a force is applied.	2	

c	Aluminium is more reactive than copper. Hence it acts as a sacrificial metal protection for copper and corrode much easily.	1 1	
d	To conserve metal as it is a finite resource or To reduce pollution as extraction of metal might produce harmful waste products	1	A: any other plausible reason

Qn.	Description	Mark	Remarks
5a	1. Purple solution turned colourless. 2. Effervescence observed.	1 1	
b	$C_2O_4^{2-}$ is the reducing agent. $C_2O_4^{2-}$ is oxidised to form CO_2. <u>The oxidation state of C increases from +3 in $C_2O_4^{2-}$ to +4 in CO_2.</u>	1 1	
c	No. of moles of $KMnO_4$ used = 25/1000 x 0.5 = 0.0125 mol No. of moles of CO_2 produced = 0.0125 x (10/2) = 0.0625 mol Volume of CO2 produced = 0.0625 x 24 = 1.50 dm^3	1 1 1	

<table>
<tr><th>Qn.</th><th>Description</th><th>Mark</th><th>Remarks</th></tr>
<tr><td>6</td><td>
<table>
<tr><td>electrolyte used</td><td>electrodes used</td><td>product formed at positive electrode</td><td>product formed at negative electrode</td></tr>
<tr><td>aqueous sodium nitrate</td><td>silver and iron</td><td>hydrogen</td><td>iron ions</td></tr>
<tr><td>any silver salt solution</td><td>silver and iron</td><td>silver</td><td>iron ions</td></tr>
<tr><td colspan="4">1m: electrolyte
1m. product at positive electrode
1m. product at negative electrode</td></tr>
</table>
</td><td>3</td><td></td></tr>
</table>

Qn.	Description	Mark	Remarks
7a	Reading increase over time as more bromine is formed. Fluorine is more reactive than bromine, hence fluorine displaces bromine from potassium bromide solution to form bromine and potassium fluoride solution. Solution turns from colourless to reddish brown over time causing the reading to increase	1 1 1	
bi	 1m: cation 1m: anion	2	
bii	Similarity: reading increases over time Difference: reading is higher in experiment 1 than in experiment 2	1 1	

Qn.	Description	Mark	Remarks
8a	From graph, % mass loss = 15% Mass loss = 250 x 15% = <u>37.5</u> ≈ mass of 2 mol of water molecules Chemical formula of P : <u>$CuSO_4.3H_2O$</u>	1 1	
bi	$2CuO + C \rightarrow 2Cu + CO_2$	1	
bii	Molten **R** conducts electricity with free mobile ions while molten **S** conducts electricity with <u>mobile/ delocalised electrons</u>.	1	
biii	**S** will <u>remain unchanged</u> while <u>**R** will be electrolysed/ decomposed.</u>	1	

Qn.	Description	Mark	Remarks
9ai	Cracking	1	
aii	$CH_3CH_2CH_2CH_2CH_3$		
aiii	Add <u>aqueous bromine</u> to both W and X. If reddish brown aqueous bromine turns from <u>brown to colourless rapidly</u>, sample is X, If aqueous bromine <u>remains reddish brown</u>, sample is W.	1 1	
b	By adding acidified potassium manganate (VII) to mixture. If it remains purple, it means all have been converted. Or By checking whether the substance boils at the fixed boiling point of butanoic acid.	1	

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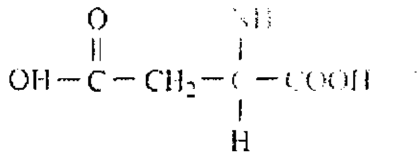
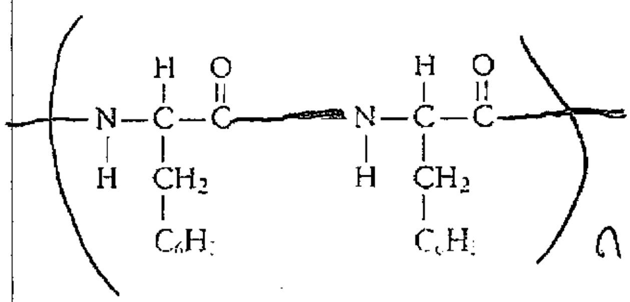
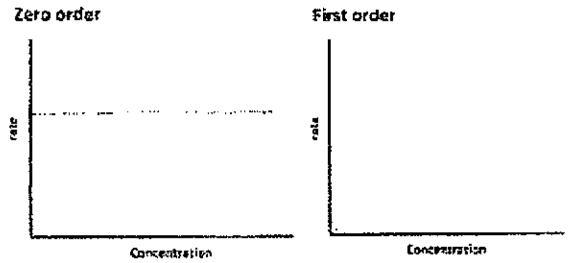
PAPER 2 SECTION B [30 marks]

Qn.	Description	Mark	Remarks
10a	• Carboxylic acid • Amide • Ester • Amine Any two of the above.	1	
bi		1	
bii	• They have the same general formula, $C_nH_{2n+1}OH$. • They contain the same –O – H functional group • Each successive member of the series differ by a $-CH_2$ unit. Any two of the above.	2	
ci	Methyl propanoate	1	
cii	• Used in flavourings • Used as solvents Any one above	1	
di	Macromolecules are large molecules built up from small units/molecules	1	
dii		1	

Qn.	Description	Mark	Remarks
11ai	1. Measure the change in colour of the solution due to the formation of I_2 over time or 2. Measure the change in electrical conductivity of solution over time	1	
aii	Student 1 is correct. Comparing experiment 1 & 2, when the concentration of $S_2O_8^{2-}$ is doubled, the initial rate of reaction also doubles. $\frac{2.44 \times 10^{-3}}{1.22 \times 10^{-3}} = 2$ Comparing experiment 4 & 5 / 1 & 4, when the concentration of I^- is doubled, the initial rate of reaction is doubled $\frac{4.88 \times 10^{-3}}{2.44 \times 10^{-3}} = 2$	1 1 1 (for both calculations)	
aiii		2 (1m for each correct graph)	
aiv	Initial rate of reaction : 4.88×10^{-3} mol/dm^{3}s Concentration of $S_2O_8^{2-}$: 0.016 mol/dm^3	1 1	
bi	Fe^{2+} acts as a catalyst. It speeds up the rate of reaction (by providing an alternative pathway with lower activation energy) and remain chemically unchanged at the end of the reaction.	1 1	

bii	1. Add sodium hydroxide/potassium hyroxide to precipitate out the insoluble iron (II) hydroxide 2. filter to remove the iron (II) hydroxide precipitate.	1 1	

EITHER

Qn.	Description	Mark	Remarks
12ai	$2NiS + 3O_2 \rightarrow 2NiO + 2SO_2$	1	
ai	no. of moles of NiS= $\frac{182000}{59+32}$ =2000 mol 2000 x (32 +16x2) = 128 kg	1 1	
b	magnesium is more reactive than carbon ; thus manufacture by <u>electrolysis</u> (of its ore) instead of reduction by carbon;	1 1	
ci	simple covalent molecule/ simple molecular structure with It has a low boiling point which is probably due to the need for little amount of energy to overcome the weak intermolecular forces of attraction between the molecules.	1 1	
cii	no visible change	1	
d	blue solution turned green nickel coated with pink solid	1 1	

OR

Qn.	Description	Mark	Remarks
12a	$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ $Zn + 2HCl \rightarrow ZnCl_2 + H_2$ No.of moles of zinc used = 0.488/65 = 0.00751 mol	1	

	No. of moles of acid used = 2.0 x 20.0/1000 = 0.04 mol Zinc is the limiting reagent in both reactions and will produce the same volume (180 cm^3) of hydrogen	1 1	
b	A is the reaction with sulfuric acid Curve A has a steeper gradient than curve B which means experiment A has a faster rate of reaction. Given the acid concentration is the same, since sulfuric acid is dibasic while hydrochloric acid is monobasic, the concentration of H^+ present in sulfuric acid is twice as much as in hydrochloric acid. Hence rate is faster for reaction with sulfuric acid.	1 1	
ci	Sulfuric acid Curve C shows the same initial gradient as curve A which means they have the same initial rate of reaction	1	
cii	No. of moles of hydrogen = 90/24000 = 0.00375 mol mass of zinc = 0.00375 x 65 = 0.244 g ; Or half the volume of hydrogen, therefore half the mass of zinc so 0.488/2 = 0.244 g ;	1	
d	$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$ OR	1	

	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ zinc displaces copper from copper(II) sulfate to produce brown copper deposit less zinc reacts with acid to produce less hydrogen ;	 1 1	

Admiralty Secondary School
Marking Scheme
4E Pure Chemistry (Paper 3)
PRELIMINARY EXAMINATION 2021

Qn	Indicative material	Mark	Total
1(a)	full set of data (5 time taken values) + correct trend (increasing)	1	[4]
	accurate calculation of average speed of reaction	1	
	all time taken recorded to nearest second	1	
	accurate calculated speed to 3 s.f.	1	
1(b)	axis labels + units	1	[4]
	appropriate scale *(y-axis to cover at least 2/3 of paper)*	1	
	all points correctly plotted	1	
	best fit line (0,0 is not a data point)	1	
1(c)	Trend: The larger the volume of P used, the higher the average speed of reaction.	1	[3]
	Explain: Larger volume of P, higher concentration of P, more P particles per unit volume	1	
	Higher frequency of collision and higher frequency of effective collision, hence higher speed of reaction.	1	
1(d)	No of moles of P to use = (0.18 x 25) / 1000 = 0.00450 mol	1	[2]
	Volume of P to draw from 0.2 mol/dm^3 P = (1000 x 0.0045) / 0.2 = 22.5 cm^3	1	
1(e)	value from graph AND indication shown to determine from x = 22.5 cm^3 allow ECF from 1(d)	1	[1]
1(f)	Change to the experiments • Use burette/pipette • Repeat each set of experiment a few imes and find average of time taken	1	[2]
	Explanation (to match change suggested) • More accurate (than measuring cylinder)	1	

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

- To reduce the human reaction time error

</td><td></td><td></td></tr>
<tr><td>1(g)</td><td>

- Start from origin
- Steeper gradient
- [if original best fit line does not pass through origin, can accept line where all the y-values are higher than the original best fit line, even if gradient seems to be the same]

</td><td>1</td><td></td></tr>
<tr><td>1(h)</td><td>

<u>Procedures</u>

1. Perform the procedures detailed in Experiment 1. This time round, use a thermometer to measure the temperature of solution P before adding to Q. Record the temperature, T_0, to the nearest °C. [1]

2. Repeat Step 1 for four more times with the temperature of solution P at T_0+10, T_0+20, T_0+30 and T_0+40 respectively. [1]

3. Record the temperature of P, to the nearest °C, and time taken, to the nearest second, for mixture to turn blue-black

<u>Results</u>

Temperature of solution P / °C	Time taken / s
T_0 =	
T_0 + 10 =	
T_0 + 20 =	
T_0 +30 =	
T_0 +40 =	

[1]

<u>Data Processing</u>

If the time-taken for the blue-black colour to appear for every increase in 10 °C of solution P is halved, then the suggestion is confirmed. [1]

<u>Assumptions</u>

1. Solution P is stable to heating and will react with Q normally
2. The temperature difference between each successive mixture when P is added to Q is approximately 10 °C even though solution Q and the starch solution is not heated.

1 mark awarded for any one of the above two points.

</td><td></td><td>[5]</td></tr>
</table>

Note: Supervisors are asked to carry out the following experiment to ensure that results fall within the required limits.

To 10.0 cm^3 of Q, add 2 cm^3 of starch solution and then add 25cm^3 of P.

The time taken for the mixture to turn blue-black should be within 15-25 s.

To adjust the time taken, increase or decrease the concentration of P.

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Setter's results for Question 1:

experiment	volume of **Q** / cm^3	volume of starch / cm^3	volume of **P** / cm^3	volume of water / cm^3	time taken / s	$\frac{1}{\text{time taken}}$ / s^{-1}
1	10	2	25	0	19	0.0526
2	10	2	20	5	26	0.0385
3	10	2	15	10	32	0.0313
4	10	2	10	15	63	0.0159
5	10	2	5	20	138	0.00724

Qn	Test	Observations	Mark	Total
2(a)	**Test 1** Place 2 cm^3 of **R** in a test tube and add equal volume of aqueous silver nitrate	Yellow/pale yellow ppt formed.	1	[12]
	Add dilute nitric acid to the mixture.	No changed is observed.	1	
	Test 2 Place 1 cm^3 of **R** in a test tube and add an equal volume of aqueous copper(II) sulfate.	(Colourless solution turned brown.) A pale brown ppt is produced. *$2KI(aq) + CuSO_4\ (aq) \rightarrow\ 2CuI(s) + I_2(aq) + K_2SO_4$*	1	
	Add aqueous sodium thiosulfate to the mixture until no further change take place.	Brown ppt (turned to *white ppt)* and soluble in excess to form colourless solution *{ $Na_2S_2O_3$ – reducing agent}* *I_2(brown soln) $\rightarrow$ I^- (colourless solution*	1	
	Test 3 Place 2 cm^3 of **R** in a test tube and add an equal volume of dilute sulfuric acid and a few drops of **S**.	Colourless solution turned reddish brown/brown	1	
	Add an excess of solution **S** to the mixture and allow to stand for a few minutes	The brown solution turns dark brown/ black ppt formed. *$2KI(aq) + H_2SO_4(aq) + H_2O_2 \rightarrow I_2(aq) + K_2SO_4(aq) + H_2O(l)$*	1	
	Test 4 Place 2 cm^3 of acidified potassium manganate(VI) solution in a test tube and add equal volume of **S**. Leave the mixture to stand for a few minutes.	Purple acidified potassium manganate (VII) solution turned from purple to colourless. Effervescence observed. (Colourless gas produced relights the glowing splint. Gas is oxygen.)	1 1	
	Test 5	Colourless/Light green solution turns to pale yellow or orange or	1	

	To 1 cm^3 of aqueous iron(II) sulfate add an equal volume of **S**. Leave the mixture to stand for a few minutes, shaking occasionally. To the mixture, add sodium hydroxide until is no further change is seen.	brown solution/ On standing brown ppt formed (Effervescence observed. The gas produced relights the glowing splint. Gas is oxygen.) Reddish brown ppt formed Effervescence observed. The gas produced relights the glowing splint. Gas is oxygen.	1 1 1	
2(b)	Anion **R** is <u>**iodide ion, I^- ion**</u> Reasoning: In **Test 1**, a yellow precipitate of silver iodide is formed with silver nitrate solution. *The precipitate is insoluble in dilute nitric acid.* $Ag^+ (aq) + I^- (aq) \rightarrow AgI(s)$		1 1	[2]
2(c)	Chemical property of solution **R** is a reducing agent Reasoning: **In Test 3**, colourless solution of iodide ion is oxidized to brown iodine solution.		1 1	[2]
2(d)	Chemical property of solution **S** is an oxidizing/reducing agent. Reasoning: • Reducing agent: In **Test 4**, purple acidified potassium manganate (VII) solution is reduced to colourless Mn^{2+} solution. • Oxdising agent: **Test 3**, colourless I^- solution is oxidized to brown I_2 or **Test 5**, the pale green Fe^{2+}solution is oxidized to yellow Fe^{3+} solution.		1 1	[2]