GREENDALE SECONDARY SCHOOL
Preliminary Examination 2024

STUDENT NAME

CLASS 4 | TEACHING GROUP | REG. NO

CHEMISTRY
Paper 1 Multiple Choice

6092/01
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, teaching group and register number in the spaces provided above and on the Multiple Choice Answer Sheet provided.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

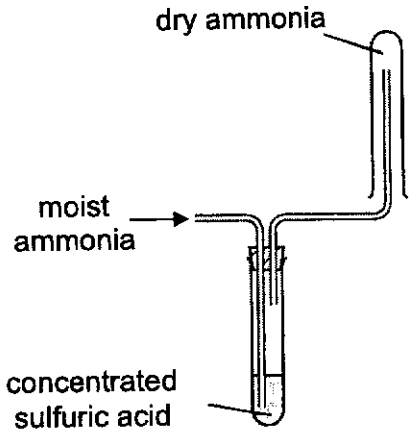
Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 20.
The use of an approved scientific calculator is expected, where appropriate

1 A student is provided with two drying agents: concentrated sulfuric acid and calcium oxide.

Which method should he use to collect a sample of dry ammonia?
[M_r: NH_3, 17]

A



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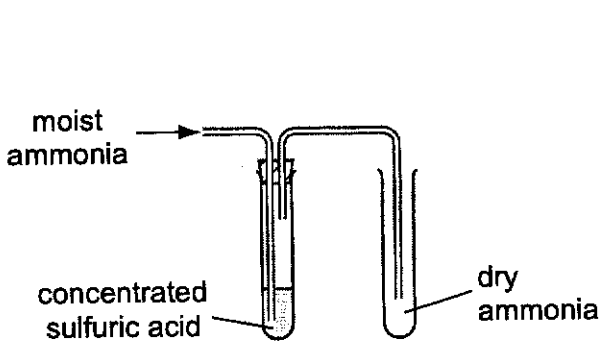

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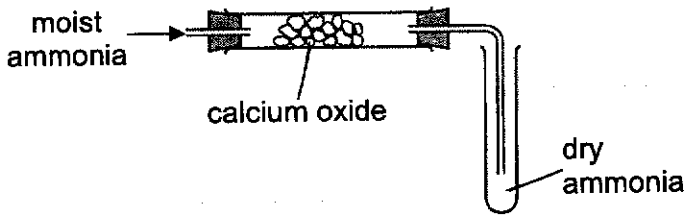

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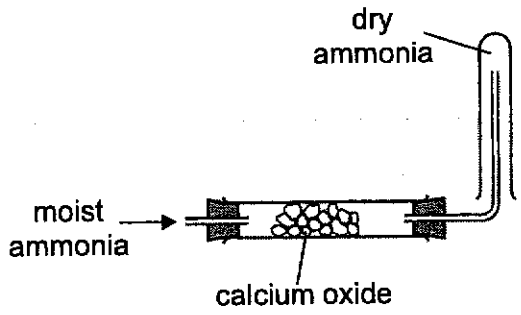
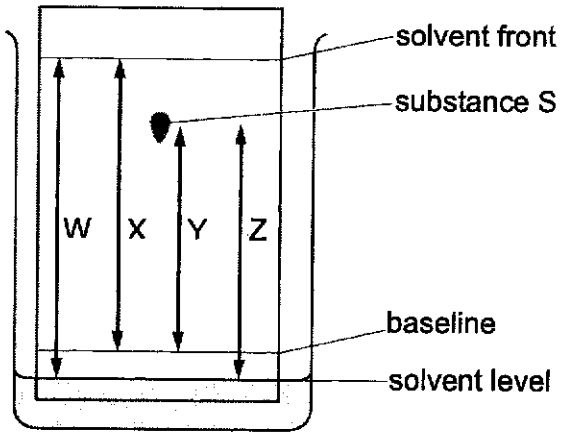


2 Which ion contains the same number of electrons as $^{56}_{26}Fe^{3+}$?

A $^{59}_{27}Co^{3+}$ **B** $^{52}_{24}Cr^{2+}$ **C** $^{56}_{25}Mn^{2+}$ **D** $^{55}_{25}Mn^{3+}$

3 The chromatogram of substance S is shown.

Some distances, W, X, Y and Z, are labelled on the diagram.

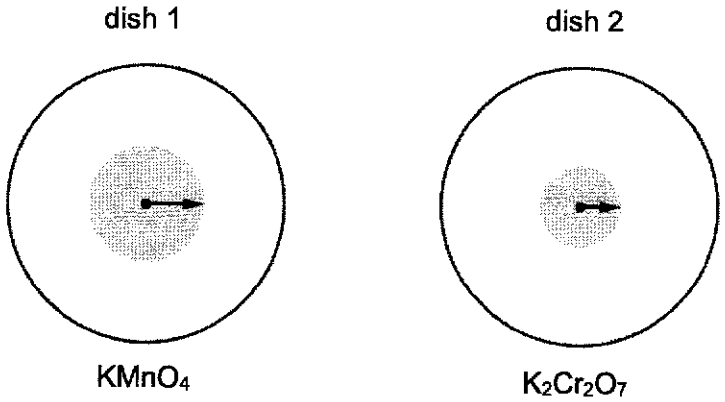


How is the R_f value of substance S calculated?

A $\frac{X}{Y}$ **B** $\frac{W}{Z}$ **C** $\frac{Y}{X}$ **D** $\frac{Y}{W}$

4 Small crystals of purple $KMnO_4$ (M_r = 158) and orange $K_2Cr_2O_7$ (M_r = 294) were placed at the centres of separate petri dishes filled with agar jelly. They were left to stand under the same physical conditions.

After some time, the colour of each substance had spread out as shown.



The lengths of the arrows indicate the relative distances travelled by particles of each substance.

Which statement is correct?

A Diffusion is faster in dish 1 because the mass of the particles is greater.

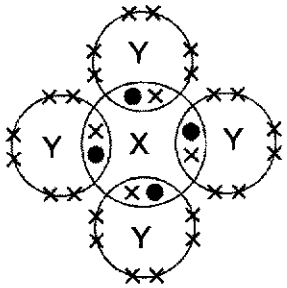
B Diffusion is faster in dish 2 because the mass of the particles is greater.

C Diffusion is slower in dish 1 because the mass of the particles is smaller.

D Diffusion is slower in dish 2 because the mass of the particles is greater.

5 A compound, XY_4, is shown below.

Both atoms of elements X and Y combine to obtain the electronic configuration of neon.



Which row shows the correct group of elements X and Y and the number of non-bonding electrons in one molecule of XY_4?

	group of X	group of Y	number of non-bonding electrons
A	14	17	24
B	14	17	34
C	17	14	24
D	17	14	34

6 How many sodium ions are there in 30 g of sodium sulfate, Na_2SO_4?

A 1.52×10^{23} **B** 2.54×10^{23}

C 1.20×10^{24} **D** 6.02×10^{24}

7 20 cm^3 of propene was reacted with 150 cm^3 of oxygen.

The equation for the reaction is shown.

$$2C_3H_6(g) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

What is the **total** volume of gas, measured at room temperature and pressure, that **remained** at the end of the reaction?

A 60 cm^3 **B** 90 cm^3 **C** 120 cm^3 **D** 180 cm^3

8 Bromobutane, C_4H_9Br, can be made from butanol, C_4H_9OH, using the reaction shown.

$$C_4H_9OH + HBr \rightarrow C_4H_9Br + H_2O$$

In an experiment, 10 g of C_4H_9OH produced 12 g of C_4H_9Br.

What is the percentage yield of C_4H_9Br?

[M_r: C_4H_9OH, 74; C_4H_9Br, 137]

A 45% **B** 54% **C** 65% **D** 83%

9 Calcium carbonate reacts with dilute hydrochloric acid according to the equation shown.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

10 g of calcium carbonate is reacted with 100 cm^3 of 1.0 mol / dm^3 hydrochloric acid.

The following statements are made.

1 1.20 dm^3 of carbon dioxide is formed.
2 5.55 g of calcium chloride is formed.
3 4.80 g of carbon dioxide is formed.
4 No calcium carbonate is left when the reaction is completed.

Which statements about the reaction are correct?

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

10 The following statements describe acids, alkalis and water.

1 Hydrochloric acid is acidic because it contains H^+ ions and no OH^- ions.
2 Nitric acid is acidic because it contains more H^+ ions than OH^- ions.
3 Sodium hydroxide is alkaline because it contains OH^- ions and no H^+ ions.
4 Water is neutral because the concentration of H^+ ions is equal to the concentration of OH^- ions.

Which statements are correct?

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 2 and 4

11 Beryllium hydroxide is an amphoteric white solid.

Which reagent can be used to distinguish beryllium hydroxide from solid calcium hydroxide?

1 HC*l*(aq)
2 HNO_3(aq)
3 KOH(aq)
4 NaOH(aq)

A 1 or 2 **B** 1 or 3 **C** 2 or 4 **D** 3 or 4

12 Which method should be used to make a pure sample of potassium chloride?

A adding AgC*l*(s) to KNO_3(aq)
B adding excess K_2CO_3(s) to HC*l*(aq)
C mixing KNO_3(aq) with NaC*l*(aq)
D titrating KOH(aq) with HC*l*(aq)

13 50.0 cm^3 of hydrochloric acid has a pH of 1.0.

This acid requires 25.0 cm^3 of aqueous sodium hydroxide to be neutralised.

A second 50.0 cm^3 solution contains the weak acid, ethanoic acid.

The hydrochloric acid and ethanoic acid have the same concentration.

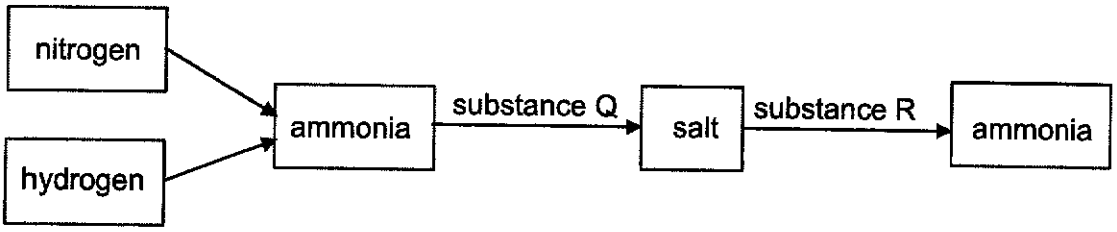
How will the pH of ethanoic acid and the volume of NaOH needed for neutralisation differ, if at all, from the hydrochloric acid?

	pH	volume of NaOH needed for neutralisation
A	higher than HC*l*	lower than for HC*l*
B	higher than HC*l*	equal to HC*l*
C	lower than HC*l*	lower than for HC*l*
D	lower than HC*l*	equal to HC*l*

14 Ammonia is produced by the reaction of the elements hydrogen and nitrogen in the Haber process.

One of these elements is obtained from crude oil.

The ammonia formed can be reacted with substance Q to form a salt.
Ammonia can be displaced from this salt by reacting with substance R.



Which row correctly shows the element obtained from crude oil and the types of substances corresponding to Q and R?

	element obtained from crude oil	substance Q	substance R
A	hydrogen	acid	base
B	hydrogen	base	acid
C	nitrogen	acid	base
D	nitrogen	base	acid

15 A mixture W, containing two compounds, is tested with different reagents.

The results are shown.

reagent	observation
excess aqueous ammonia followed by filtration	green precipitate and colourless solution
dilute nitric acid and aqueous silver nitrate	no visible reaction
dilute nitric acid and aqueous barium nitrate	white precipitate
warm with aqueous sodium hydroxide and aluminium foil	moist red litmus paper remains red

What are the two salts in solution W?

A ammonium chloride and calcium sulfate

B calcium nitrate and iron(II) chloride

C iron(II) sulfate and zinc nitrate

D iron(II) sulfate and zinc sulfate

16 The following substances are used in the laboratory to test for various gases.

acidified potassium manganate(VII)	aqueous sodium hydroxide	blue litmus paper
limewater	red litmus paper	wooden splint

When testing for ammonia, chlorine, hydrogen and oxygen, what is the **minimum** number of items from the table above needed to identify these four gases?

A 2 **B** 3 **C** 4 **D** 5

17 Which pairs of statements correctly describe the differences between the conduction of electricity during electrolysis and the conduction of electricity by metals?

	conduction during electrolysis	conduction by metals
1	The current is due to the movement of both positive and negative ions.	The current is due to the movement of electrons.
2	Charged particles move towards both electrodes.	Charged particles move in one direction only.
3	It results in a chemical change.	It does not result in a chemical change.

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

18 Chemical Z is a powerful oxidising agent.

Which statement about Z is correct?

A Z reacts with aqueous potassium iodide producing a brown solution and gains electrons in the process.

B Z reacts with aqueous potassium iodide producing a brown solution and loses electrons in the process.

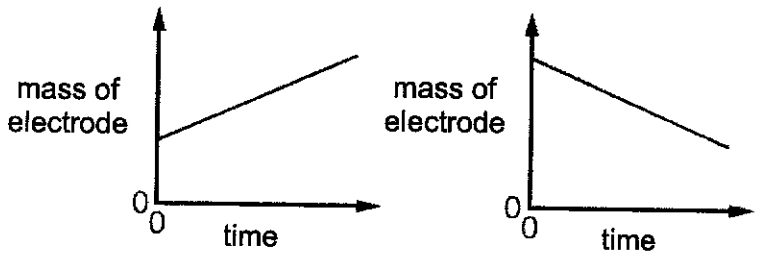
C Z decolourises acidified potassium manganate(VII) and gains electrons in the process.

D Z decolourises acidified potassium manganate(VII) and loses electrons in the process.

19 Impure copper can be purified via electrolysis, using copper electrodes and dilute aqueous copper(II) sulfate as the electrolyte.

The current is constant and the positive and negative electrodes are weighed at regular time intervals.

The following graphs were obtained when the mass of the positive and negative electrodes are plotted against time.



1 2

Which row correctly describes the electrolytic cell and the respective graphs obtained?

	negative electrode	positive electrode	graph for negative electrode	graph for positive electrode
A	impure copper	pure copper	1	2
B	impure copper	pure copper	2	1
C	pure copper	impure copper	1	2
D	pure copper	impure copper	2	1

20 Three statements about fuel cells are given.

1 A hydrogen-oxygen fuel cell requires a continuous input of fuel and oxygen.

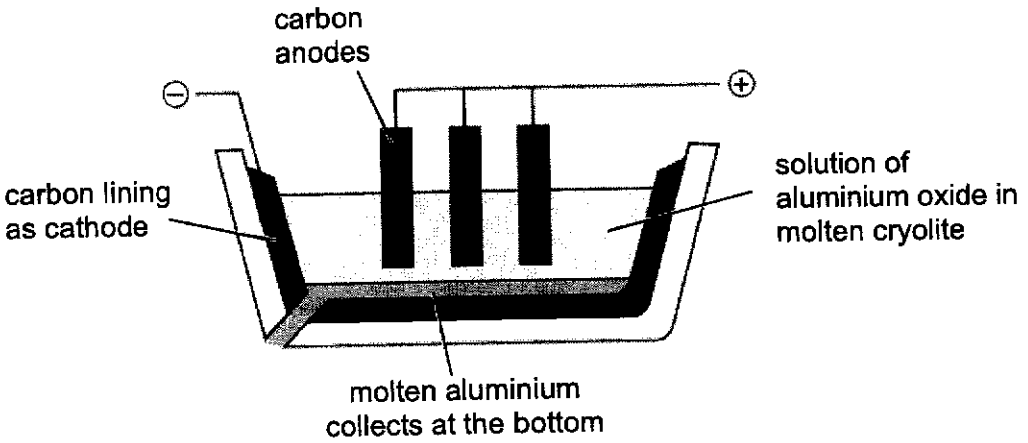
2 In a hydrogen-oxygen fuel cell, hydrogen is burned in oxygen to produce electricity.

3 When a hydrogen-oxygen fuel cell is operating, water is the only chemical product.

Which statements are correct?

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

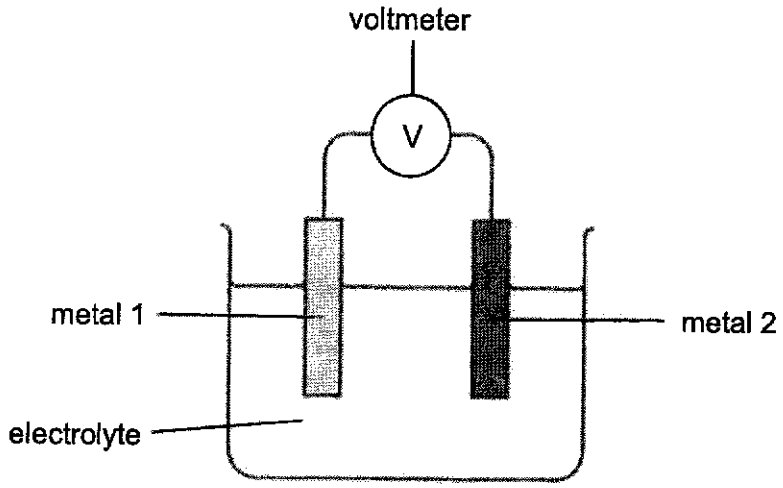
21 The apparatus used for the extraction of aluminium by electrolysis of molten aluminium oxide is shown.



Which row correctly describes the electrolysis of molten aluminium oxide?

	negative electrode	positive electrode
A	aluminium ions oxidised to aluminium	oxide ions reduced to oxygen
B	aluminium ions reduced to aluminium	oxide ions oxidised to oxygen
C	oxide ions oxidised to oxygen	aluminium ions reduced to aluminium
D	oxide ions reduced to oxygen	aluminium ions oxidised to aluminium

22 Two metal electrodes and an electrolyte can be used to produce electrical energy.



The table shows the voltage produced by some cells when different metals are used.

metal 1	metal 2	voltage / V
silver	zinc	1.56
silver	nickel	1.06
silver	iron	1.25
silver	magnesium	K
copper	iron	L

Which row best describes the voltage values K and L, and the relative reactivity of nickel?

	voltage K	voltage L	relative reactivity of nickel
A	greater than 1.56 V	greater than 1.25 V	more reactive than iron but less reactive than zinc
B	less than 1.56 V	less than 1.25 V	more reactive than both iron and zinc
C	greater than 1.56 V	less than 1.25 V	less reactive than both iron and zinc
D	less than 1.56 V	greater than 1.25 V	less reactive than both iron and zinc

23 X is a Group 1 metal, more reactive than sodium.

Y and Z are Group 17 elements.

When X reacts with Y, a salt is formed. A solution of this salt reacts with Z to form a different salt.

What are X, Y and Z?

	X	Y	Z
A	K	Cl_2	I_2
B	Li	Cl_2	Br_2
C	Li	Br_2	Cl_2
D	K	I_2	Cl_2

24 Some properties of metals are listed.

1 forms chloride of formula X*Cl* only, where X is the metal

2 forms coloured compounds

3 high density

4 its presence can lower the activation energy of a reaction

5 low melting point

Which row shows the properties of group 1 metals and transition metals?

	properties of group 1 metals	properties of transition metals
A	1 and 5	2, 3 and 4
B	1, 4 and 5	2 only
C	2, 3 and 4	1 and 5
D	2 and 3	1 and 4 only

25 An equal number of moles of metal carbonates XCO_3 and ZCO_3 are heated strongly.

They both decompose and release a gas.

The time taken for the compound to decompose completely is measured.

metal carbonate	time taken to decompose / s
XCO_3	92
ZCO_3	266

Which row describes the reactivity of the metals and the suggested method of extraction of each metal from its compound?

	reactivity of metals X and Z	method of extraction of X	method of extraction of Z
A	X is more reactive than Z	electrolysis	reduction with carbon
B	X is more reactive than Z	reduction with carbon	electrolysis
C	Z is more reactive than X	electrolysis	reduction with carbon
D	Z is more reactive than X	reduction with carbon	electrolysis

26 Two large pieces of iron are placed in water.

In experiment 1, a small piece of copper is attached to the iron.

In experiment 2, a small piece of magnesium is attached to the iron.

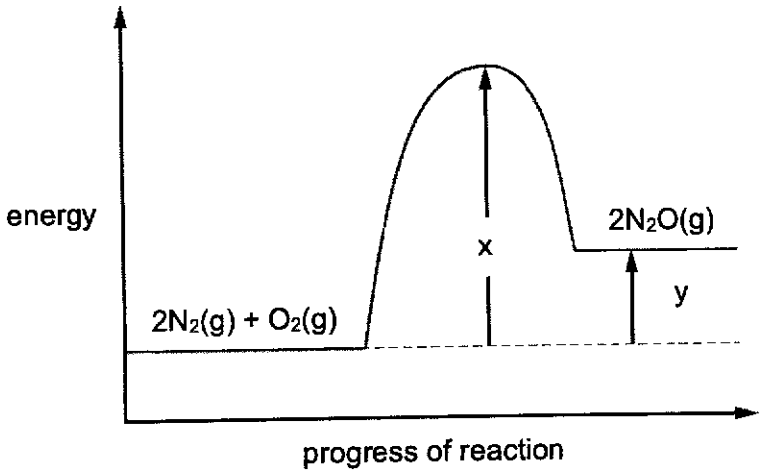
Which are the equations for reactions that would take place in experiment 1 and experiment 2?

	experiment 1	experiment 2
A	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$
B	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$
C	$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$	$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$
D	$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$	$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$

27 Under certain conditions, nitrogen reacts with oxygen to form N_2O.

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$$

The reaction pathway diagram is shown.



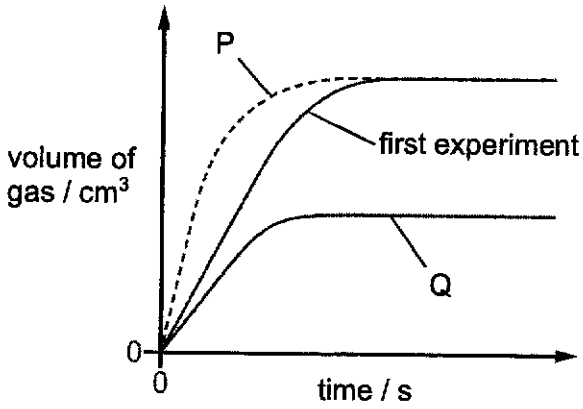
Which of the following correctly represents the enthalpy change and activation energy for the forward and backward reactions?

	forward reaction		backward reaction	
	enthalpy change	activation energy	enthalpy change	activation energy
A	x – y	x	y – x	y
B	y	x	–y	x – y
C	x – y	y	y – x	y
D	y	x – y	–y	x – y

28 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 25 cm^3 of more concentrated of acid and Q has a lower temperature.

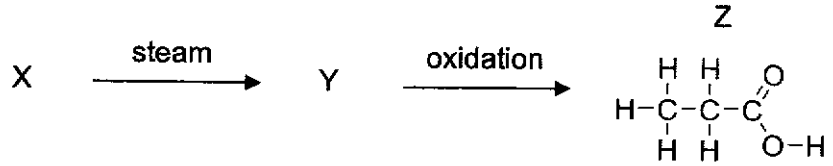
B P uses higher temperature and Q uses 25 cm^3 of more dilute acid.

C P uses higher temperature and Q uses smaller pieces of solid.

D P uses smaller pieces of solid and Q uses larger pieces of solid.

29 X reacts with steam to form Y.

Y is oxidised to form Z.

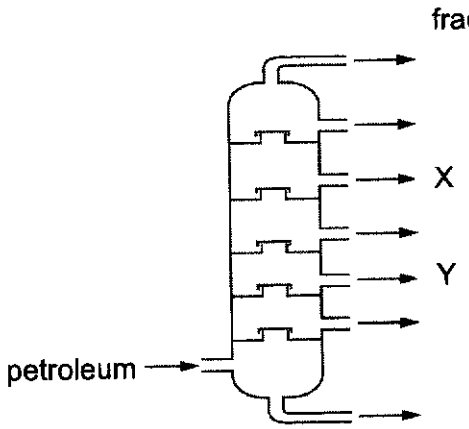


What are the formulae of X and Y?

	formula of X	formula of Y
A	C_3H_6	C_3H_7O
B	C_3H_6	C_3H_8O
C	C_3H_8	C_3H_7O
D	C_3H_8	C_3H_8O

30 Petroleum (crude oil) is separated into useful fractions by fractional distillation.

The positions at which fractions X and Y are collected from the fractionating column are shown.



Which statements are **not** correct?

1 The temperature increases up the column.
2 X condenses at a lower temperature than Y.
3 X has longer chain molecules than Y.
4 X is more flammable than Y.

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

31 The reactants and products of two reactions are shown.

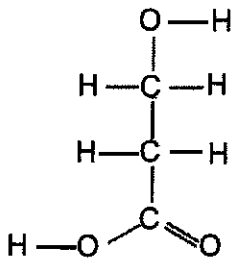
reaction 1 $C_2H_6 + Cl_2 \rightarrow X + HCl$

reaction 2 $C_{17}H_{36} \rightarrow 2C_2H_4 + C_3H_6 + 2Y + H_2$

Which row correctly describes these two reactions?

	formula of X	conditions for reaction 1	reaction 2	Y
A	C_2H_5Cl	in the dark	cracking	saturated
B	$C_2H_4Cl_2$	in the dark	substitution	unsaturated
C	$C_2H_4Cl_2$	in ultraviolet light	cracking	saturated
D	C_2H_5Cl	in ultraviolet light	cracking	unsaturated

32 The structure of hydracrylic acid is shown.



A student added the following reagents to hydracrylic acid.

1 acidified potassium manganate(VII)

2 aqueous sodium carbonate

3 Universal Indicator

Which row correctly identifies the results obtained that correspond to the experiments?

	acidified potassium manganate(VII)	aqueous sodium carbonate	Universal Indicator
A	colourless to purple	effervescence occurred	green to yellow
B	purple to colourless	effervescence occurred	green to orange
C	purple to colourless	effervescence occurred	green to blue
D	purple to colourless	no effervescence	green remains

33 A vegetable oil is polyunsaturated.

Which statement about this vegetable oil is **not** correct?

A It has many carbon – carbon double bonds.

B It reacts with hydrogen to form a solid compound.

C It will turn colourless aqueous bromine brown.

D Nickel catalyst is added when forming margarine from vegetable oil.

34 There are two isomers of butene, C_4H_8. Their structures are given below.

$CH_2=CHC_2H_5$ $CH_3CH=CHCH_3$

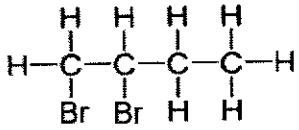
The following statements are made about the isomers.

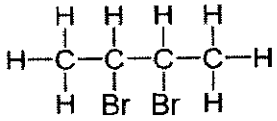
1 Combustion of 1 mole of each produces equal numbers of moles of both carbon dioxide and water.

2 Both produce the same molecule when reacted with hydrogen.

3 When polymerised, the same polymer is produced.

4 The following are the possible products from the reaction between bromine and each isomer.

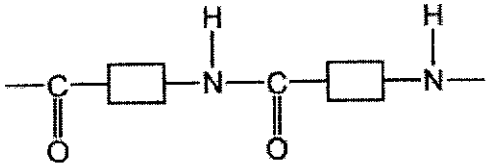




Which statements are correct?

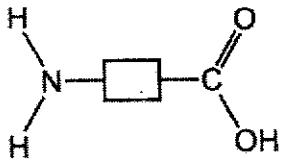
A 1, 2 and 4 **B** 1 and 2 only **C** 2 and 3 only **D** 2, 3 and 4

35 The partial structure of a polyamide is shown.



Which monomers would produce this polymer?

1



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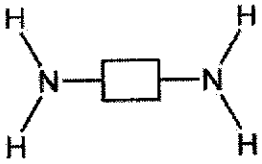

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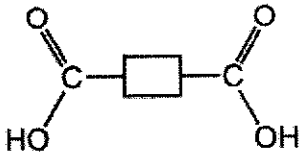


A 1 only **B** 1 and 2 **C** 1 and 3 **D** 2 and 3

36 A pure fat has a molecular mass of 400.

100 g of the fat reacts with 127 g of iodine, I_2.

How many moles of carbon – carbon double bonds are there in each molecule of the fat?

A 1 mol **B** 1.5 mol **C** 2 mol **D** 4 mol

37 Carbon dioxide and methane are both greenhouse gases.

Which activity produces both of these gases?

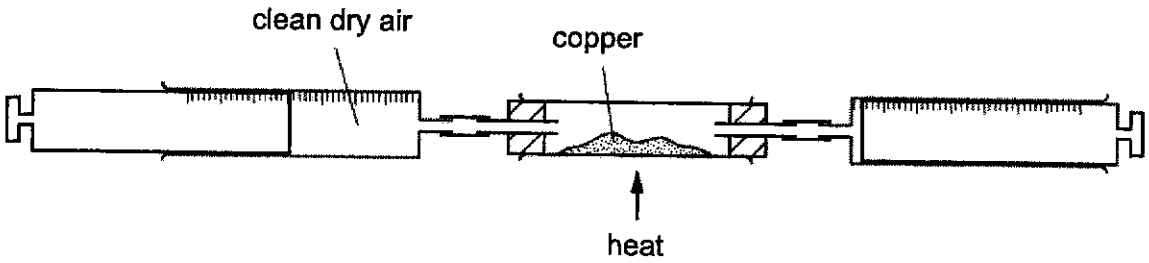
A farming animals

B cracking alkanes

C the thermal decomposition of calcium carbonate

D using petrol-powered cars

38 A sample of clean, dry air is passed repeatedly over hot copper until all the oxygen reacts with the copper as shown.



The volume of air decreases by 25 cm^3.

What is the starting volume of the sample of air?

A 50 cm^3 **B** 75 cm^3 **C** 100 cm^3 **D** 120 cm^3

39 Which gas will react with ozone in the upper atmosphere of the Earth?

A CF_2Cl_2 **B** CH_4 **C** CO_2 **D** CF_4

40 The carbon cycle includes the processes combustion, photosynthesis and respiration.

Which row shows how each process changes the amount of carbon dioxide in the atmosphere?

	combustion	photosynthesis	respiration
A	decreases	decreases	increases
B	decreases	increases	decreases
C	increases	decreases	increases
D	increases	increases	decreases

END OF PAPER

The Periodic Table of Elements

Group 1	2											13	14	15	16	17	18
							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	3	4	5	6	7	8	9	10	11	12	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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).

The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$

GREENDALE SECONDARY SCHOOL
Preliminary Examination 2024

STUDENT NAME

CLASS 4 | TEACHING GROUP | REG. NO

CHEMISTRY
Paper 2

6092/02
1 hour 45 minutes

Student answer on the Question Paper.
No Additional Materials are Required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, teaching group and register number in the spaces provided above.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section **A**
Answer **all** questions.
Write your answers in the spaces provided.

Section **B**
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 32.

The use of an approved scientific calculator is expected, where appropriate.

Section A

Answer **all** questions.

1 Two chloride salts, iron(II) chloride and lead(II) chloride are made from the same acid but different preparation methods.

(a) Complete Table 1.1, in identifying the reactants to prepare iron(II) chloride and lead(II) chloride salts.

Table 1.1

salt	reactants	
	acid	other reactant
iron(II) chloride	hydrochloric acid	iron(II) carbonate
lead(II) chloride		lead(II) nitrate

[2]

(b) Use Table 1.1 to name the resulting solution formed during the preparation of lead(II) chloride salt.

solution formed: ..... [1]

(c) While preparing iron(II) chloride, a student added one of the reactants in excess.

Use Table 1.1 to identify which reactant must be added in excess for the preparation of iron(II) chloride.

Explain your reasoning.

.....

.....[1]

[Total: 4]

2 **(a)** Fig. 2.1 shows the structure of compound **A**.

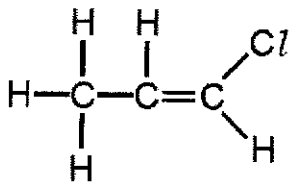


Fig. 2.1

Compound **A** can be polymerised.

Draw **two** repeating units of the polymer formed when compound **A** is polymerised.

[1]

(b) Poly(ethene) is an example of a polymer that can be recycled.

Describe one physical method and one chemical method used to recycle this polymer.

physical method .....

.....

chemical method .....

.....

[2]

(c) **(i)** Fig. 2.2 shows two monomers that react together to produce a polymer.

monomer 1 monomer 2

Fig. 2.2

Draw the structure of the repeating unit of the polymer produced from monomers 1 and 2.

[1]

(ii) The repeating unit for a different polymer is shown in Fig. 2.3.

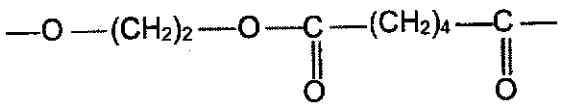


Fig. 2.3

Suggest **one** similarity and **one** difference between the monomers used to make this polymer and those used to make the polymer in **(c)(i)**.

.....

.....

.....

.....[2]

(iii) Name the type of linkage found in the polymer formed in **(c)(i)** and the polymer shown in Fig. 2.3.

polymer formed in **(c)(i)**: .....

polymer shown in Fig. 2.3: .....

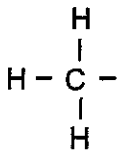
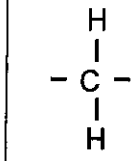
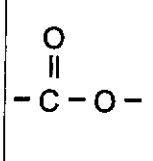
[1]

[Total: 7]

3 Compounds **A** and **B** are isomers.

Table 3.1 shows some information about the isomers **A** and **B**.

Table 3.1

isomer	description of isomer			empirical formula	M_r	pH of 0.1 mol/dm^3 of solution
						
A	✓	✓	✓	C_2H_4O	88	3
B	✓	×	✓	C_2H_4O	88	3

✓ – presence of unit
× – absence of unit

(a) Which data in Table 3.1 supports the statement that **A** and **B** are isomers?

.....

.....[1]

(b) Use the information in Table 3.1 to deduce and draw the structural formula for isomers **A** and **B**.

Show all atoms and bonds.

isomer **A**

isomer **B**

[2]

(c) The structure of another isomer of **A** and **B** is shown in Fig. 3.1.

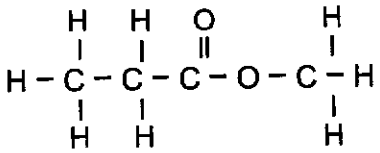


Fig. 3.1

Draw the displayed formula of the carboxylic acid and the alcohol that react to form the isomer in Fig. 3.1.

alcohol	carboxylic acid

[2]

(d) Another compound **R** is from the same homologous series as isomers **A** and **B**.

Compound **R** contains of 62.1% carbon, 10.3% hydrogen and 27.6% oxygen.

Deduce the **empirical formula** of compound **R**.
Show your working.

[2]

[Total: 7]

4 Fig. 4.1 shows some elements in the Periodic Table.

	1	2	13	14	15	16	17	18
Period 2	**Li**			**C**		**O**	**F**	
Period 3	**Na**						**Cl**	
Period 4	**K**						**Br**	
Period 5	**Rb**						**I**	

Fig. 4.1

(a) Put a tick (✓) in **one** box for each row to show whether the following statements about the trends of some of these elements in Fig. 4.1 are true or false.

	true	false
Atoms lose electrons more easily down group 1.		
Melting point decreases from fluorine to iodine.		
The strongest non-metal oxidising agent is at the top of a group.		
Metallic character increases across Period 3.		

[2]

(b) Table 4.1 shows information about some of the elements in Period 2.

Table 4.1

element	melting point /°C	electrical conductivity
lithium	180.5	good
carbon (graphite)	3600	good
oxygen	–218.8	poor

Use ideas about **bonding** and **structure** to explain the differences in properties of the elements shown in Table 4.1.

.....

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.....

..... [5]

[Total: 7]

5 Table 5.1 shows some information about the hydrides of elements in Period 3 of the Periodic Table. Read the information and answer the questions that follow.

Table 5.1

element	metal / non-metal	formula of hydride	M_r of hydride	effect of adding hydride to water
Na	metal	NaH	24	reacts to form $H_2(g)$ and an alkaline solution
Mg	metal	MgH_2	26	reacts to form $H_2(g)$ and an alkaline solution
Al	metal	AlH_3	30	reacts to form $H_2(g)$ and an alkaline solution
Si	non-metal	SiH_4	32	does not react
P	non-metal	PH_3	34	reacts to form $H_2(g)$ and a slightly alkaline solution
S	non-metal	H_2S	34	reacts to form a slightly acidic solution
Cl	non-metal	H*Cl*	36.5	reacts to form an acidic solution

(a) Write a balanced chemical equation for the reaction between NaH and water.

.....[1]

(b) A student performs an experiment to test whether some hydrides react with water.

He adds each hydride to water and tests the pH of the mixture.

Explain how the result shows whether a hydride is a metal hydride or a non-metal hydride.

.....

.....

.....[1]

(c) Draw a 'dot-and-cross' diagram to show the bonding in NaH.

Show only outer electrons.

[2]

(d) Explain why sodium hydride can conduct electricity in molten state but not in solid state.

.....

.....

.....

.....[2]

(e) Two students make these statements about the percentage by mass of hydrogen in the hydrides.

Student 1: 'The greater the number of hydrogen atoms in the hydride, the greater the percentage by mass of hydrogen.'

Student 2: 'The percentage by mass of hydrogen is the same for the same number of hydrogen atoms in the hydride.'

Does the information in Table 5.1 support the statements made by students 1 and 2?

Explain your reasoning.

.....

.....

.....

.....

.....

.....[2]

[Total: 8]

6 A student investigates the progress of the reaction between 20 cm^3 of 0.1 mol/dm^3 dilute hydrochloric acid, HCl, and an excess of large pieces of marble, $CaCO_3$, using the apparatus shown in Fig. 6.1.

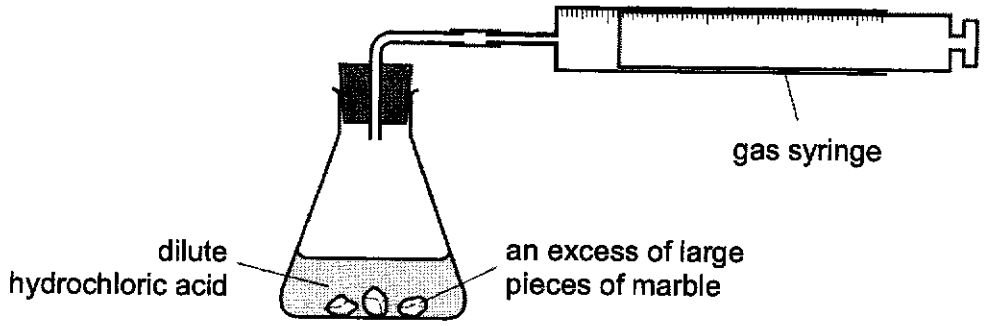


Fig. 6.1

(a) A graph of the volume of gas produced against time is shown in Fig. 6.2.

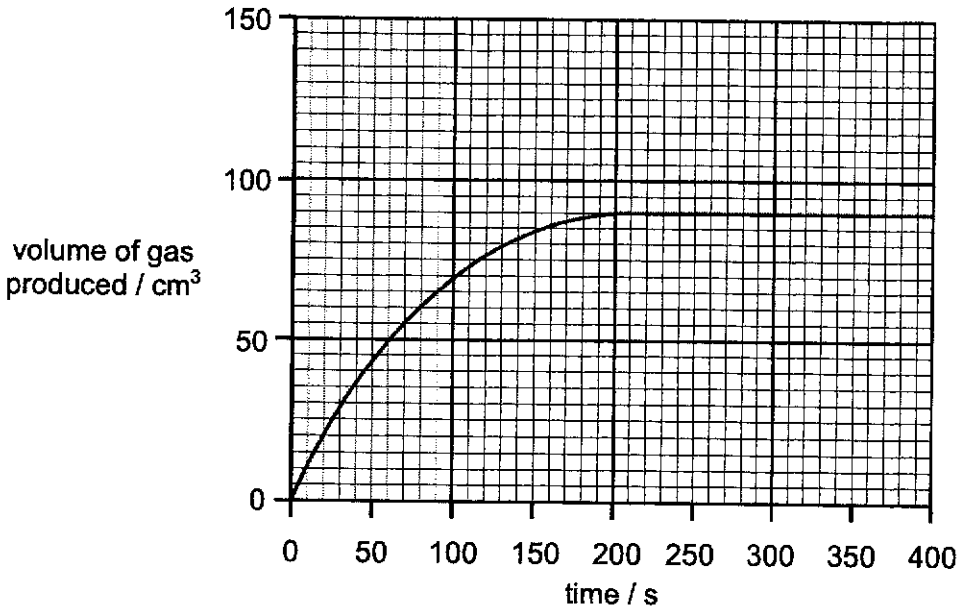


Fig. 6.2

(i) Deduce the time at which the reaction finishes.

time = ... s [1]

(ii) Calculate the average rate of the reaction for the first 90 seconds.

State the unit for the rate of reaction.

average rate of reaction = ...[1]

(b) The experiment is repeated using the

- same mass of smaller pieces of marble,
- half the volume of 0.1 mol/dm^3 of HC*l*.

All other conditions are kept the same.

Draw a line **on the grid** in Fig. 6.2 to show the progress of the reaction with the changes in conditions.

[1]

(c) The original experiment is repeated at a higher temperature.

All other conditions are kept the same.

Explain why the rate of a reaction increases when temperature increases, in terms of activation energy and collisions between particles.

.....

.....

.....

.....

.....[2]

[Total: 5]

7 Peroxodisulfate ions, $S_2O_8^{2-}$, react with iodide ions in aqueous solution.

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

Table 7.1 shows how the relative rate of this reaction changes when different concentrations of peroxodisulfate ions and iodide ions are used.

Table 7.1

experiment	concentration of $S_2O_8^{2-}$ / mol dm^{-3}	concentration of I^- / mol dm^{-3}	relative rate of reaction
1	0.008	0.02	1.7
2	0.016	0.02	3.4
3	0.032	0.02	6.8
4	0.008	0.04	3.4
5	0.008	0.08	

(a) Use information in Table 7.1 to deduce the relative rate of experiment 5.

Explain your reasoning.

.....

.....

.....[1]

(b) In experiments 4 and 5, the volume of aqueous peroxodisulfate ions used is 20 cm^3 each.

In experiments 4 and 5, the volume of aqueous iodide ions used is 10 cm^3 each.

Which is the limiting reactant at the start of experiments 4 and 5?

Show your working.

[2]

[Total: 3]

8 (a) Emissions from power stations contain the pollutant gas, sulfur dioxide.

(i) Describe one harmful effect on marble statues and metal bridges caused by sulfur dioxide.

.....

.....[1]

(ii) One way to remove sulfur dioxide is to use a 'scrubber' containing wet calcium carbonate.

The reaction of sulfur dioxide with wet calcium carbonate happens in several stages.

In the first stage, sulfur dioxide reacts with water to make an acid, H_2SO_3.

In the second stage, this acid reacts with calcium carbonate to make calcium sulfite, $CaSO_3$.

Write a chemical equation for the reaction in each stage.

equation in stage 1:

.....

equation in stage 2:

.....

[2]

(b) Car engines are adjusted to work at a particular air: fuel ratio.

The amount of air that is mixed with the fuel affects the temperature of the engine, the amount of pollutant gases that form and how efficiently the catalytic converter works.

The major pollutant gases are carbon monoxide and nitrogen monoxide.

(i) A 'lean burn' engine runs with a higher ratio of air to fuel than a normal car engine.

This means that the mixture contains a higher amount of air compared to fuel.

One effect of this is a lower running temperature of the engine.

How will a lean burn engine affect the amount of **carbon monoxide** and **nitrogen monoxide** formed compared to a normal car engine?

Explain your reasoning.

.....

.....

.....

.....

.....

.....

.....

.....

.....[3]

(ii) The catalytic converter removes pollutant gases.

The converter removes carbon monoxide and nitrogen monoxide by oxidation and reduction.

from oxidising agent ↓ $CO + [O] \rightarrow CO_2$

to reducing agent ↓ $2NO \rightarrow N_2 + 2[O]$

Write an overall equation to show how carbon monoxide and nitrogen monoxide react together in the converter.

.....[1]

(iii) Explain in terms of oxidation states, why the reactions in the catalytic converter are described as redox.

.....

.....

.....

.....[2]

[Total: 9]

9 Alkynes are a homologous series of organic compounds.

Alkynes contain the C≡C group. They react in a similar way to alkenes.

Table 9.1 shows some information about the first four alkynes.

Table 9.1

alkyne	molecular formula	boiling point / °C
ethyne	C_2H_2	–84
	C_3H_4	–23
butyne	C_4H_6	8
pentyne	C_5H_8	40

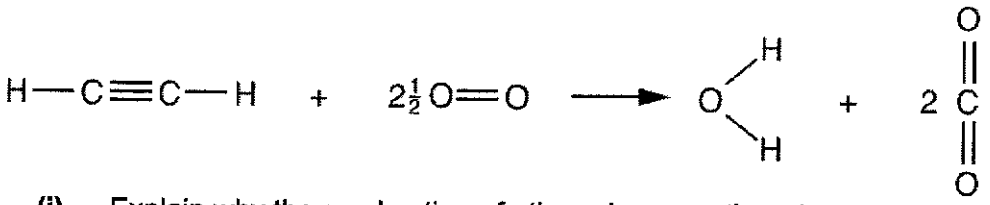
(a) Suggest the name of the alkyne with the molecular formula C_3H_4.

.....[1]

(b) Deduce the general formula of the alkyne homologous series.

.....[1]

(c) Ethyne reacts with oxygen in an exothermic reaction.



(i) Explain why the combustion of ethyne is an exothermic reaction.

Use ideas about the energy changes that take place during bond breaking and bond making.

.....

.....

.....

..... [2]

(ii) The complete combustion of one mole of ethyne releases 1410 kJ of energy.

Calculate the energy released when 1000 dm^3 of ethyne, measured at room temperature and pressure, is completely combusted.

energy released = ... kJ [2]

(d) Ethyne is bubbled through aqueous bromine.

(i) Suggest a possible molecular formula of the product of this reaction.

..... [1]

(ii) What is observed during the reaction?

..... [1]

[Total: 8]

10 Dynamic equilibrium

Reversible reactions often have a product yield much lower than 100%, and always result in a mixture of products and reactants after no further chemical change occurs.

A reversible reaction comprises of a forward reaction and a backward reaction, as shown in Fig. 10.1.

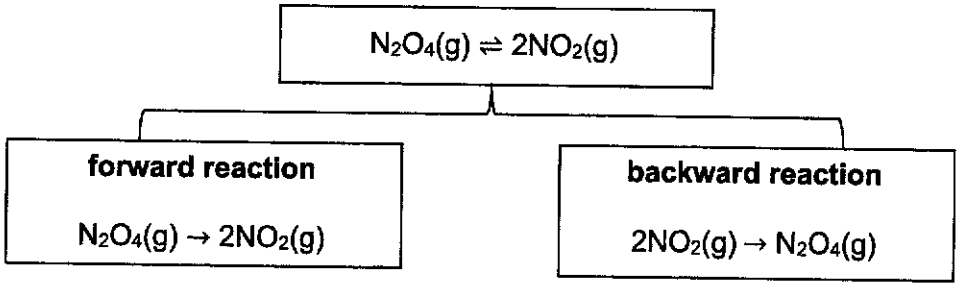


Fig. 10.1

A unique feature about reversible reactions is that both forward and backward reactions occur simultaneously.

Eventually, a state of **dynamic equilibrium** is achieved, whereby any new amount of products formed is converted back into the reactants, and the reactants are converted into products, as time passes. Hence, the system is in a state of balance, known as equilibrium. The concentration of reactants and products remain constant.

Fig. 10.2 shows a graph of forward and backward reaction rates as time passes, based on the decomposition of N_2O_4, dinitrogen tetroxide, shown in Fig. 10.1.

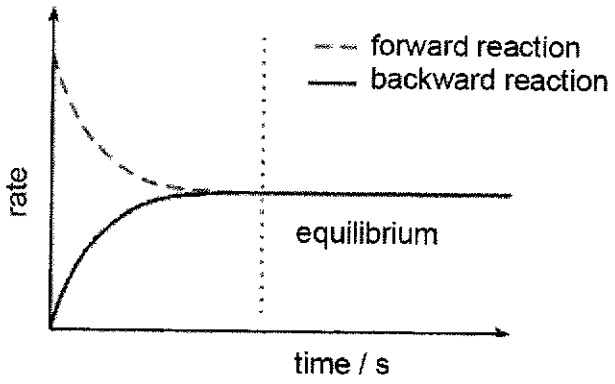


Fig. 10.2

Le Chatelier's principle

In the late 1800s, Henri Louis Le Chatelier, devised an important principle. It states that **if a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium shifts to counteract and remove the change to re-establish a new equilibrium of reactants and products.**

One way in which the equilibrium can be disturbed is by adding reactants or products to, or removing reactants or products from the mixture.

The composition of an equilibrium mixture in a reversible reaction can be affected by changes in concentration, temperature and pressure.

Factors affecting equilibrium

Changing concentration

An example is the formation of a white precipitate of bismuth oxychloride, BiOC*l*, when colourless bismuth(III) chloride, BiC*l*$_3$, is added to water.

$$BiCl_3(aq) + H_2O(l) \rightleftharpoons BiOCl(s) + 2HCl(aq)$$

Read Table 10.1 which describes the changes when excess HC*l*(aq) is added to the equilibrium mixture. This addition of excess HC*l*(aq) is a 'disturbance'.

Table 10.1

substances present at **initial** equilibrium	BiC*l*$_3$(aq), H_2O(l), BiOC*l*(s) and HC*l*(aq)
disturbance: adding excess HC*l* at equilibrium	increase in concentration of H^+(aq) and Cl^-(aq)
to counteract and remove the disturbance	shift towards the backward reaction to remove excess HC*l*(aq)
new equilibrium obtained	more BiC*l*$_3$(aq) and H_2O(l); less BiOC*l*(s)

Changing temperature

An example is the industrial manufacture of ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Read Table 10.2 which describes the changes when temperature is increased.

Table 10.2

substances present at **initial** equilibrium	N_2(g), H_2(g) and NH_3(g)
energy change for this reaction	forward reaction releases heat (exothermic); backward reaction absorbs heat (endothermic)
disturbance: increase in temperature at equilibrium	excess heat added to the reaction
to counteract and remove the disturbance	shift towards the backward reaction which absorbs the excess heat
new equilibrium obtained	more N_2(g) and H_2(g); less NH_3(g)

Changing pressure

The same example of the industrial manufacture of ammonia is used.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Read Table 10.3 which describes the changes when pressure is increased.

Table 10.3

moles of gas	moles of gaseous reactants: 1 mole of N_2 + 3 moles of H_2 = 4 moles moles of gaseous product: 2 moles of NH_3 = 2 moles
disturbance: increase in pressure at equilibrium	excess pressure in the reaction
to counteract and remove the disturbance	shift towards the forward reaction (fewer number of moles of gas) to decrease the number of moles of gas present
new equilibrium obtained	less $N_2(g)$ and $H_2(g)$; more $NH_3(g)$

(a) Use information from Fig. 10.2 to describe how the forward and backward reaction rates change over time.

.....

.....

.....

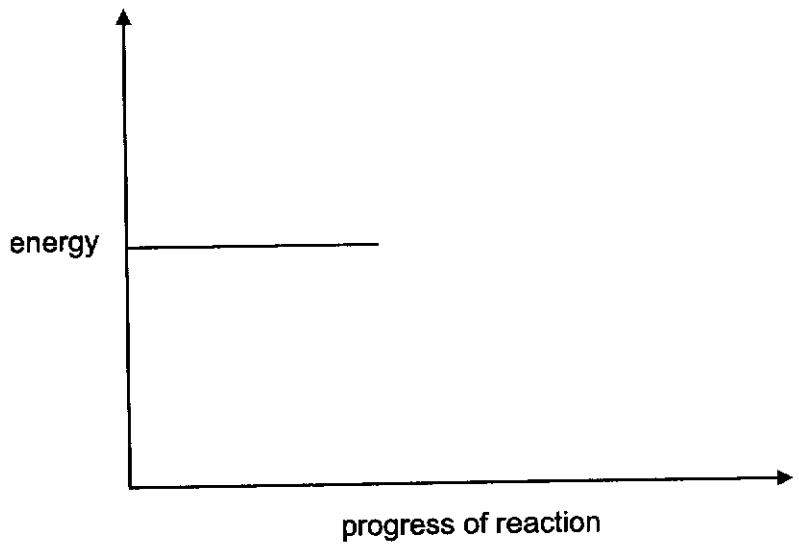
.....[2]

(b) Complete the energy profile diagram for the manufacture of ammonia.

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ ΔH = negative

Your diagram should show:

- the reactants and products of the reaction,
- the energy profile and activation energy, E_a,
- the enthalpy change of reaction, ΔH.



[3]

(c) When hydrogen ions are added to methyl orange (Meor), a red coloured complex (H-Meor) is formed.

An equilibrium mixture between the two forms of methyl orange will be established.

$$\underset{\text{red}}{\text{H-Meor(aq)}} \rightleftharpoons \text{H}^+\text{(aq)} + \underset{\text{yellow}}{\text{Meor}^-\text{(aq)}}$$

$Meor^-$ is yellow in colour.

Using Le Chatelier's Principle, suggest what you would observe when hydroxide ions are added to this equilibrium mixture.

Explain your reasoning.

.....

.....

.....

.....

.....[2]

(d) An equilibrium mixture for the formation of methanol from carbon monoxide and hydrogen is shown.

$$\text{CO(g)} + 2\text{H}_2\text{(g)} \rightleftharpoons \text{CH}_3\text{OH(g)}$$

Using Le Chatelier's Principle, predict and explain the effect of decreasing the pressure on the amount of methanol in the equilibrium mixture.

The temperature remains constant.

.....

.....

.....

.....

..... [2]

(e) At 200 °C and 200 atmospheric pressure, phosphorus(V) chloride, PCl_5, forms an equilibrium mixture with phosphorus(III) chloride, PCl_3, and chlorine, Cl_2.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

The table shows the percentage of phosphorus(III) chloride in the equilibrium mixture at different temperatures.

The pressure is the same in each case.

temperature / °C	% of PCl_3 in the mixture
200	48
300	95
400	99

(i) Describe how the composition of this equilibrium mixture changes with temperature.

.....[1]

(ii) Use your answer from **(e)(i)** and Le Chatelier's Principle to predict whether the forward reaction is endothermic or exothermic.

Explain your reasoning.

.....

.....

.....

.....

.....

.....[2]

[Total: 12]

Section B

Answer **one** question from this section.

11 **(a)** Electrolysis of dilute aqueous potassium chloride and concentrated aqueous potassium chloride were carried out separately using inert electrodes.

A few drops of Universal Indicator were added to each of the electrolyte.

The set-up is shown in Fig. 11.1 and Fig. 11.2.

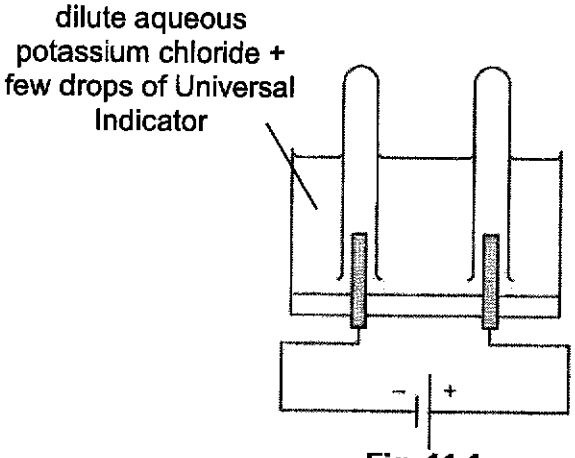


Fig. 11.1

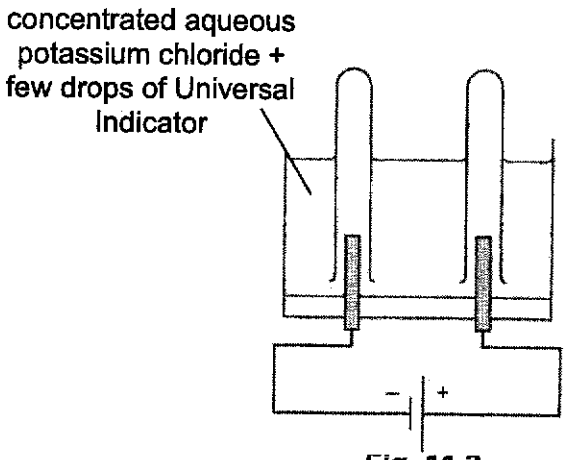


Fig. 11.2

A student made this conclusion regarding both the electrolysis.

For both of the electrolysis,
- the gaseous product at the negative electrode is the same but
- the gaseous product at the positive electrode is different.

Explain the student's conclusion and the changes to the electrolyte.

Your answer should:
- explain why the products form,
- describe and explain the changes to the Universal Indicator added to each electrolyte,
- give half-equations for the reaction at each electrode.

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[5]

(b) A new type of electroplating is known as brush electroplating. It can be used to electroplate copper onto very large iron structures.

During the electroplating process, a metal brush spreads a layer of aqueous copper(II) sulfate over the surface of the iron structure. A layer of copper metal forms on the surface of the iron support.

Fig. 11.3 shows the set-up.

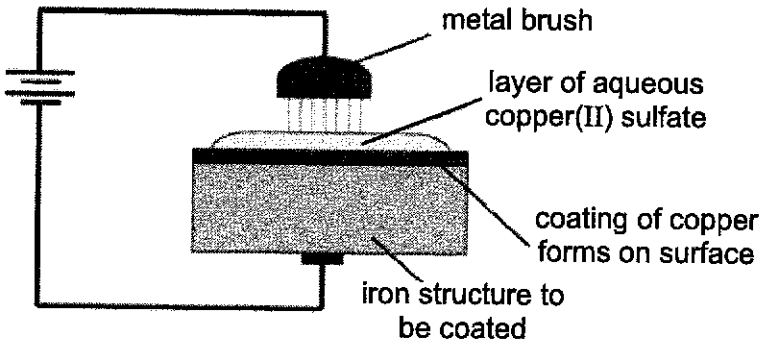

Fig. 11.3

(i) Identify each electrode in the electroplating process in Fig. 11.3.

negative electrode: .....

positive electrode: .....

[1]

(ii) Write an ionic half-equation for the formation of copper metal on the iron structure.

State symbols are **not** required.

.....[1]

(iii) Two different designs of metal brush are available.
One type of brush is made of copper while the other is made of platinum.

As the electroplating takes place, each brush has a different effect on the concentration of copper(II) ions in aqueous copper(II) sulfate.

State the effect on the concentration of copper(II) ions during the electrolysis when each brush is used.

brush made of copper:

effect: .....
[1]

brush made of platinum:

effect: .....
[1]

(iv) Platinum brushes are much more expensive than copper brushes.

However, copper brushes need replacing regularly but platinum brushes do not.

Explain why.

.....

.....

..... [1]

[Total: 10]

12 **(a)** Fig. 12.1 shows an experiment, where rods of copper and zinc are dipped into dilute sulfuric acid.

The top of each rod is touching.

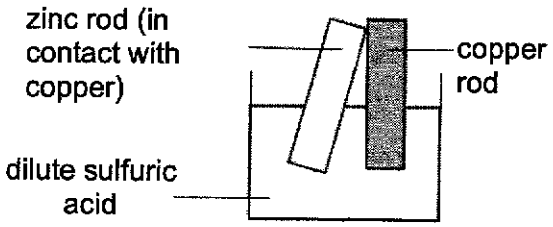

Fig. 12.1

Predict and explain the expected observations.

Your answer should:

- describe the expected observations at each piece of metal rod,
- explain why each change occurs,
- give half-equations for the reaction at each metal rod.

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[4]

(b) Table 12.1 gives some data about two fuels, hydrogen and ethanol.

Table 12.1

fuel	boiling point/ °C	density at r.t.p / g dm^{-3}	volume of 1 mol of fuel at r.t.p / dm^3	enthalpy change of combustion / kJ mol^{-1}	enthalpy change of combustion / kJ g^{-1}
hydrogen, H_2	−252	0.083	24		−143
ethanol, C_2H_5OH	78.4	789		−1367	

(i) Complete Table 12.1 by calculating the volume of 1 mol of ethanol, and the enthalpy change of combustion of hydrogen in kJ / mol and the enthalpy change of combustion of ethanol in kJ / g.

Use the space below to show your working.

[3]

(ii) Use the information in Table 12.1 to evaluate the use of hydrogen and ethanol as fuels.

Your answer should consider:

- the ease of storage,
- the energy content of the fuels.

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..... [2]

(iii) Ethanol can be manufactured from ethene and from glucose.

State which source of ethanol makes it a renewable fuel and explain your answer.

.....

.....

.....[1]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Group 1	2											13	14	15	16	17	18
							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	3	4	5	6	7	8	9	10	11	12	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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).

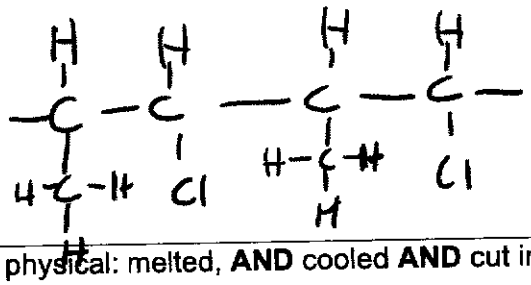
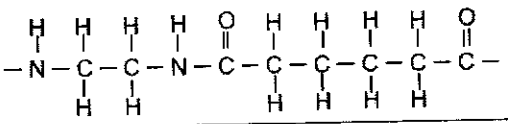
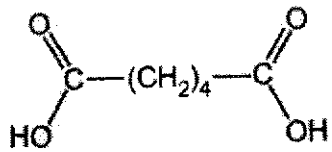
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$

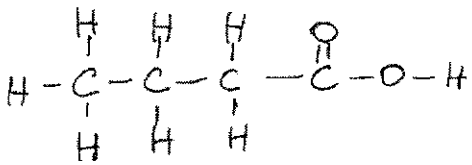
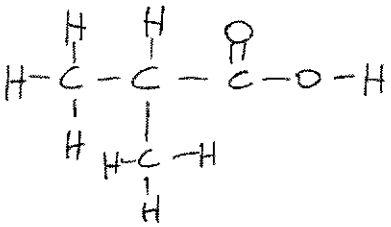
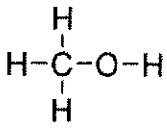
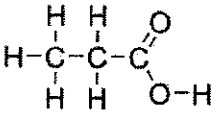
2024 Class Preliminary Examination
Chemistry
Secondary 4 Express
Suggested answers

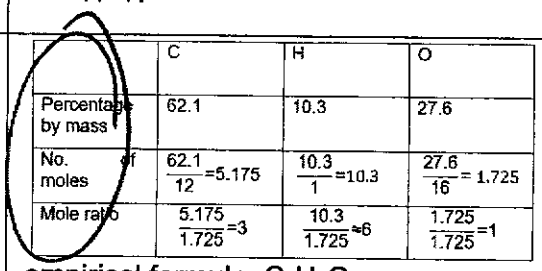
Section A

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

Section B

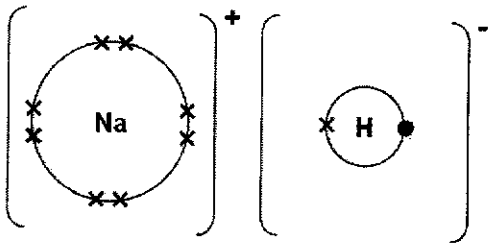
Qn	Answer	Mark
1(a)	acid: hydrochloric acid other reactant: lead(II) nitrate	[1] [1]
1(b)	nitric acid	[1]
1(c)	Iron(II) carbonate is added in excess to ensure all the acid is completely reacted / used up.	[1]
	TOTAL	[4]
2(a)		[1]
2(b)	physical: melted, **AND** cooled **AND** cut into pellets chemical: cracking to break into smaller molecules	[1] [1]
2(c)(i)		[1]
2(c)(ii)	similarity: The monomer 2 used to make both the polymers is the same dicarboxylic acid,  difference: The other monomer used to make this polymer is a diol but the other monomer in **(c)(i)** is a diamine.	[1] [1]
2(c)(iii)	**(c)(i)**: amide (linkage) **AND** Fig. 2.3: ester (linkage)	[1]
	TOTAL	[7]
3(a)	Same empirical formula **AND** M_r **AND** different arrangement of atoms / different units present.	[1]

<table>
<tr><th>Qn</th><th>Answer</th><th>Mark</th></tr>
<tr><td>3(b)</td><td>isomer A:
 
isomer B:
  </td><td>[2]</td></tr>
<tr><td>3(c)</td><td>alcohol:
 
carboxylic acid:
  </td><td>[1]

[1]</td></tr>
<tr><td>3(d)</td><td> 
empirical formula: C_3H_6O</td><td>[2]</td></tr>
<tr><td></td><td>TOTAL</td><td>[7]</td></tr>
</table>

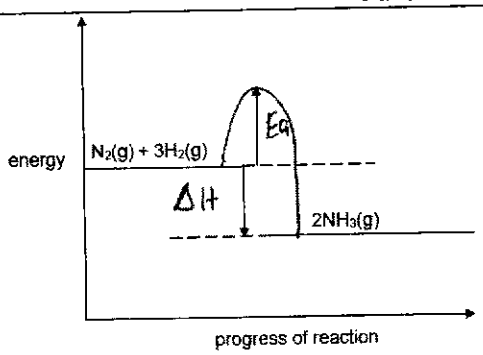
	C	H	O
Percentage by mass	62.1	10.3	27.6
No. of moles	$\frac{62.1}{12}=5.175$	$\frac{10.3}{1}=10.3$	$\frac{27.6}{16}=1.725$
Mole ratio	$\frac{5.175}{1.725}=3$	$\frac{10.3}{1.725}\approx6$	$\frac{1.725}{1.725}=1$

<table>
<tr><th>Qn</th><th>Answer</th><th>Mark</th></tr>
<tr><td>4(a)</td><td>
<table>
<tr><th></th><th>true</th><th>false</th></tr>
<tr><td>Atoms lose electrons more easily down group 1.</td><td>✓</td><td></td></tr>
<tr><td>Melting point decreases from fluorine to iodine.</td><td></td><td>✓</td></tr>
<tr><td>The strongest non-metal oxidising agent is at the top of the group.</td><td>✓</td><td></td></tr>
<tr><td>Metallic character increases across Period 3.</td><td></td><td>✓</td></tr>
</table>
</td><td>[2]</td></tr>
<tr><td>4(b)</td><td>Comparison of structure:
lithium: giant metallic structure
graphite: giant molecular structure (consisting of huge network of C atoms)
oxygen: simple molecular structure consisting of discrete molecules</td><td>[1]</td></tr>
<tr><td></td><td>Comparison of bonding:
lithium: strong electrostatic forces between lithium cations and sea of electrons
graphite: strong covalent bonds between carbon atoms
oxygen: weak intermolecular forces between discrete molecules</td><td>[1]</td></tr>
<tr><td></td><td>comparison between the melting points:
Most energy needed to overcome the strong covalent bonds between carbon atoms; hence graphite has the highest melting point AND
Least energy needed to overcome weak intermolecular forces in oxygen.</td><td>[1]</td></tr>
<tr><td></td><td>Electrical conductivity comparison:
lithium: presence of delocalised / free moving / mobile electrons to conduct electricity
AND
oxygen: exist as molecules and no mobile charge carriers / no free moving electrons or ions to conduct electricity</td><td>[1]</td></tr>
</table>

Qn	Answer	Mark
	graphite: each C atom is bonded to 3 other atoms and 1 free / non-bonded electron per C atom and there are free moving electrons to conduct electricity.	[1]
	TOTAL	**[7]**
5(a)	$NaH + H_2O \rightarrow NaOH + H_2$	[1]
5(b)	If the pH of the mixture is less than 10, it is a non-metal hydride; **AND** If the pH of the mixture is more than 10, it is a metal hydride;	[1]
5(c)		[2]
5(d)	In solid state, ions held in fixed position / no free moving ions to conduct electricity.	[1]
	In molten state, giant (crystal)/ (ionic) lattice structure breaks down **AND** free moving ions to conduct electricity.	[1]
5(e)	Student 1 is correct. **AND** SiH_4 has the most number of H atoms; % by mass of hydrogen in SiH_4 = 4/28 x 100% = 12.5% This is the highest compared to the rest: Eg: 3/30 = 10% for H in AlH_3 Student 2 is wrong. **AND** Given the same number of H atoms, Eg: % of H in PH_3 = 3/34 x 100% = 8.8% % of H in AlH_3 = 3/30 x 100% = 10%	[1] [1]
	TOTAL	**[8]**
6(a)(i)	200 s	[1]
6(a)(ii)	average rate = 65/90 = <u>0.722 cm^3 / s</u>	[1]
6(b)	Gradient is larger than original / steeper **AND** Volume of gas produced is half – levels off at 45 cm^3	[1]

Qn	Answer	Mark
6(c)	Particles gain energy and move faster **OR** Greater fraction / more particles have energy greater than or equal to activation energy ;	[1]
	Frequency of effective collisions increases, increasing rate of reaction ;	[1]
	TOTAL	**[5]**
7(a)	6.8 **AND** Comparing experiments 1 and 4, when concentration of $S_2O_8^{2-}$ ions is constant, concentration of I^- is doubled, rate of reaction is also doubled. **AND** comparing expt 4 and 5, concentration of iodide is doubled, rate from expt 4 to 5 should be 3.4 x 2 = 6.8	[1]
7(b)	amount $S_2O_8^{2-}$ ions in both experiments = 20/1000 x 0.008 = 0.00016 mol **AND** amount of I^- ions in expt 4 = 10/1000 x 0.04 = 0.0004 mol **AND** amount of I^- ions in expt 5 = 10/1000 x 0.08 = 0.0008 mol Mole ratio: $S_2O_8^{2-}$: I^- 1 : 2 0.00016 : 0.00032 needed Since only 0.00032 mol needed to react with 0.00016 mol of $S_2O_8^{2-}$, I^- ions in excess in both experiments, hence **$S_2O_8^{2-}$ ions is the limiting reactant.**	[1] [1]
	TOTAL	**[3]**
8(a)(i)	Reacts / dissolves in rain water to form acid rain **AND** Corrodes metal and limestone buildings	[1]
8(a)(ii)	equation in stage 1: $SO_2 + H_2O \rightarrow H_2SO_3$ equation in stage 2: $H_2SO_3 + CaCO_3 \rightarrow CaSO_3 + H_2O + CO_2$	[1] [1]

Qn	Answer	Mark
8(b)(i)	As air to fuel ratio is higher, • higher concentration of O_2 in air • occurrence of incomplete combustion of petrol is less **AND** • lead to less carbon monoxide formed. As the temperature of the internal combustion engine is lower, • O_2 and N_2 from air will less likely combine to form nitrogen monoxide. • lead to less nitrogen monoxide formed.	[1] [1] [1]
8(b)(ii)	$2CO + 2NO \rightarrow N_2 + 2CO_2$	[1]
8(b)(iii)	Oxidation state of carbon increases from +2 in CO to +4 in CO_2; hence carbon undergoes oxidation. Oxidation state of nitrogen decreases from +2 in NO to 0 in N_2; hence nitrogen undergoes reduction.	[1] [1]
	TOTAL	**[9]**
9(a)	propyne	[1]
9(b)	C_nH_{2n-2}	[1]
9(c)(i)	Energy absorbed to break 1 mole of C≡C bond, 2 moles of C – H bonds and 2.5 moles of O=O bonds is <u>less</u> than the energy released to make 2 moles of O – H bonds and 4 moles of C=O bonds.	[2]
9(c)(ii)	Amount of C_2H_2 = 1000/24 = 41.67 / 41.7 mol Energy released = 41.67 x 1410 = 58 750 kJ / 58 800 kJ	[1] [1]
9(d)(i)	$C_2H_2Br_2$ / $C_2H_2Br_4$	[1]
9(d)(ii)	Reddish-brown aqueous bromine turns colourless.	[1]
	TOTAL	**[8]**
10(a)	Forward reaction rate decreases over time, while backward reaction rate increases. Eventually, both forward and backward reaction rates are equal/same.	[1] [1]

Qn	Answer	Mark
10(b)		[3]
10(c)	turned yellow/ orange	[1]
	idea of hydroxide ions reacting with hydrogen ions **AND** increase / shift towards the forward reaction / more $Meor^-$ is present in equilibrium	[1]
10(d)	3 moles of gaseous reactant and 1 mole of gaseous product / counteract the decrease in pressure / to increase pressure;	[1]
	shift towards the backward reaction **AND** less methanol produced as pressure decreases	[1]
10(e)(i)	percentage of PCl_3 increases as temperature increases;	[1]
10(e)(ii)	increase temperature, more PCl_3 formed hence shift towards the forward reaction to remove the heat "disturbance"	[1]
	forward reaction must be endothermic, (as reaction mixture absorbs heat)	[1]
	TOTAL	**[12]**

Section C

Qn	Answer	Mark
11(a)	**similarity at negative electrodes:** At the negative electrode: H^+ ions selectively discharged (over K^+) in both electrolytes as hydrogen is below potassium in the reactivity series; **AND** $2H^+(aq) + 2e^- \rightarrow H_2(g)$	[1]
	Electrolysis of dilute potassium chloride: **At the positive electrode:** OH^- ions selectively discharged (over Cl^- ions), forming oxygen gas; **AND** $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$	[1]
	electrolysis of concentrated potassium chloride: **At the positive electrode:** Cl^- ions selectively discharged over OH^- ions as higher concentration of chloride ions, forming chlorine gas. **AND** $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$	[1]
	Electrolysis of dilute potassium chloride: **Electrolyte:** K^+ and Cl^- ions remain in the electrolyte, Universal Indicator remains green.	[1]
	electrolysis of concentrated potassium chloride: **Electrolyte:** K^+ and OH^- ions remain in the electrolyte, increase in concentration of OH^- ions over H^+ ions. Universal Indicator changes from green to violet / purple / blue.	[1]
11(b)(i)	negative electrode: iron structure / iron / support **AND** positive electrode: metal brush	[1]
11b(ii)	$Cu^{2+} + 2e^- \rightarrow Cu$	[1]
11(b)(iii)	effect: concentration of Cu^{2+} ions remains the same / unchanged	[1]
	effect: concentration of Cu^{2+} ions decreases	[1]

Qn	Answer	Mark
11(b)(iv)	Copper brush will be oxidised to form Cu^{2+} ions and will dissolve. **AND** Platinum is inert and will not be oxidised.	[1]
	TOTAL	**[10]**
12(a)	zinc electrode: zinc is more reactive than copper and hence is preferentially oxidised. **AND** $Zn \rightarrow Zn^{2+} + 2e^-$	[1]
	H^+ ions are selectively discharged as hydrogen is below zinc in the reactivity series, at the copper electrode. **AND** $2H^+ + 2e^- \rightarrow H_2$	[1]
	observation at zinc rod: zinc dissolves / decreases in mass / size	[1]
	observation at copper rod: bubbles of gas observed	[1]
12(b)(i)	Volume of ethanol = (12 x 2 + 5 + 16 + 1) / 789 = 0.0583 dm^3	[1]
	Mass of 1 mole of H_2 = 2 g 1 g produces 143 kJ 2 g (1 mol) = 143 x 2 = 286 kJ produced –286 kJ/mol	[1]
	Mass of 1 mole of ethanol = 46 g 1 g of ethanol produces 1367/46 = –29.7 kJ / g	[1]
12(b)(ii)	Burning the same mass of hydrogen produces / releases more energy than burning ethanol; 143 kJ for 1 g hydrogen compared to 29.7 kJ for 1 g of ethanol. **OR** Burning the same amount of hydrogen produces less energy than burning ethanol; 286 kJ for 1 mol of hydrogen compared to 1367 kJ for 1 mol of ethanol	[1]
	At r.t.p, ethanol is a liquid while hydrogen exist as a gas. H_2 will occupy a larger volume for storage of 24 dm^3 compared to ethanol of 0.0583 dm^3 for 1 mol of each fuel.	[1]

Qn	Answer	Mark
	OR Density of hydrogen of 0.083 g/dm^3 is smaller than density of ethanol of 789 g/dm^3, indicating less mass of hydrogen can be stored in fixed volume.	
12(b)(iii)	Ethanol obtained from glucose **AND** glucose is obtained from plants which can be regrown and replaced within a short period of time.	[1]
	TOTAL	**[10]**