O

ANDERSON SECONDARY SCHOOL
Preliminary Examination
Secondary Four Express

CANDIDATE NAME:

CLASS: / INDEX NUMBER:

CHEMISTRY **6092/01**

Paper 1 Multiple Choice **23 August 2024**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
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.

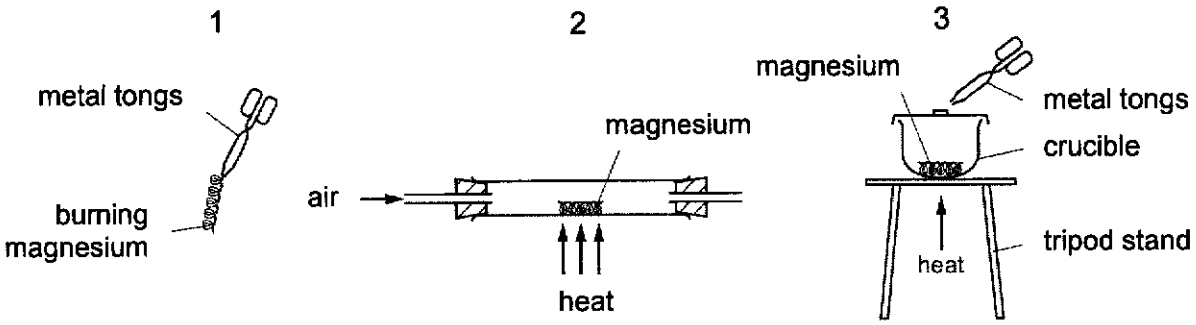
There are **forty** questions on this paper.
Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in pencil on the separate Answer Sheet.

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 18.
The use of an approved scientific calculator is expected, where appropriate.

1 When heated, magnesium undergoes combustion to form magnesium oxide, a white powder.

A student investigates the change in mass that occurs during this reaction. The student is given a balance and three sets of apparatus as shown.



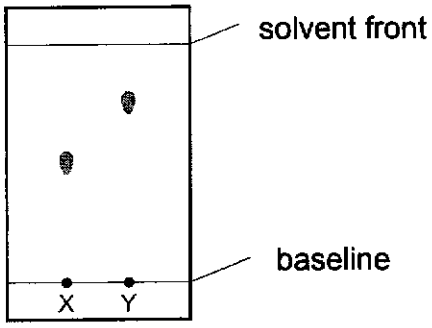
Which sets of apparatus are suitable for this investigation?

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

2 The results of a paper chromatography experiment are shown, which is **not** drawn to scale.

X is an aqueous solution of a salt of a Group 1 element.

Y is an aqueous solution of a salt of a transition element.



Which row is correct?

	larger R_f value	requires a locating agent
A	X	X
B	X	Y
C	Y	X
D	Y	Y

3 A laboratory has a powdered mixture of solid iodine and solid carbon.

Iodine is very soluble in hexane and slightly soluble in water. Carbon is insoluble in both solvents.

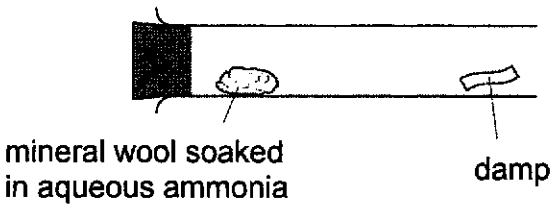
One sample of the mixture is shaken with hexane. This is P.

Another sample of the mixture is shaken with water. This is Q.

Which procedure is used to prepare a pure sample of iodine?

A P is distilled and the distillate is evaporated to dryness.
B P is filtered and the filtrate is allowed to evaporate to dryness.
C P is filtered and the residue is allowed to evaporate to dryness.
D Q is distilled and the distillate is evaporated to dryness.

4 Mineral wool soaked in aqueous ammonia is placed in the apparatus shown.

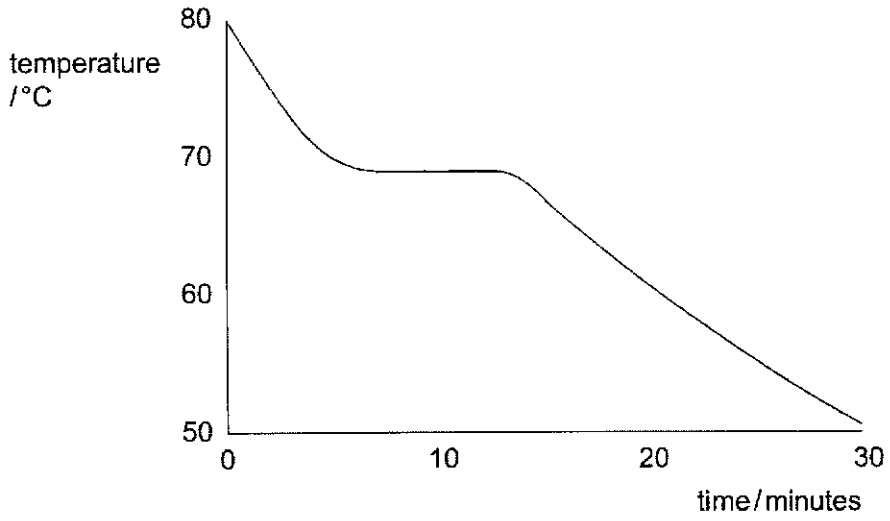


After 5 minutes, the damp red litmus paper turns blue.

Which process led to this change?

A condensation
B crystallisation
C diffusion
D fractional distillation

5 Stearic acid has a melting point of 69°C.
A heated sample of pure stearic acid is cooled, and the temperature is recorded every minute for 30 minutes. A graph of the results is shown.



Which process occurs between 8 and 12 minutes?

A boiling
B condensing
C freezing
D melting

6 The number of electrons, protons and neutrons in four different particles are shown.

particle	electrons	protons	neutrons
1	19	19	20
2	18	19	20
3	20	20	20
4	19	19	22

Which particles are isotopes of the same element?

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

7 Element E and element G react together to form a compound.

The electronic configurations of E and G are 2,8,3 and 2,6 respectively.

Which row is correct?

	element E	element G	type of compound
A	2 atoms each loses 3 electrons	3 atoms each gains 2 electrons	covalent
B	2 atoms each loses 3 electrons	3 atoms each gains 2 electrons	ionic
C	2 atoms each gains 3 electrons	3 atoms each loses 2 electrons	covalent
D	2 atoms each gains 3 electrons	3 atoms each gains 2 electrons	ionic

8 Which substance has a giant covalent structure and contains atoms of more than one element?

A ammonia
B diamond
C graphite
D silicon dioxide

9 Three statements about the properties of metals are shown.

1 All metals conduct electricity.
2 All metals have 2 electrons in their innermost shell.
3 All metals have high melting points.

Which statements are correct?

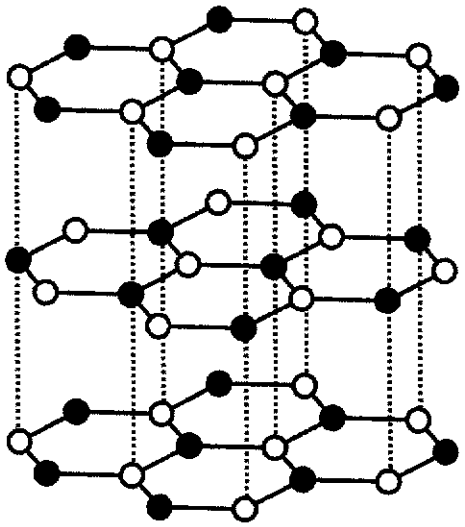
A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3

10 Element J forms a positive ion when it reacts with oxygen.

Using the Periodic Table, how many protons are in atom J?

A 6 **B** 10 **C** 16 **D** 20

11 The diagram shows the structure of boron nitride.



key:
● boron
○ nitrogen

Which statement about boron nitride is correct?

A It has a low melting point.
B It has an ionic lattice.
C It has the same structure as diamond.
D It can be used as a lubricant.

12 Three compounds are listed.

- calcium carbonate
- potassium sulfate
- zinc nitrate

Which row shows the element present in the greatest percentage by mass in each compound?

	element present in the greatest percentage by mass in calcium carbonate	element present in the greatest percentage by mass in potassium sulfate	element present in the greatest percentage by mass in zinc nitrate
A	calcium	oxygen	oxygen
B	calcium	oxygen	zinc
C	oxygen	potassium	zinc
D	oxygen	potassium	oxygen

13 Samples of two hydrated compounds are weighed and then dehydrated by heating.

The anhydrous compounds are weighed and the results are shown.

3.97g $FeSO_4.xH_2O$ gives 2.17g anhydrous $FeSO_4$.

2.88g $CaSO_4.yH_2O$ gives 2.27g anhydrous $CaSO_4$.

What are the values of x and y?
[M_r: $FeSO_4$, 152; $CaSO_4$, 136; H_2O, 18]

	x	*y*
A	5	2
B	5	5
C	7	5
D	7	2

14 50.0 cm^3 of 0.100 mol/dm^3 silver nitrate, $AgNO_3$, is added to 150.0 cm^3 of 0.0500 mol/dm^3 sodium iodide, NaI, in a beaker.

After the reaction, solid silver iodide is present in the beaker.

What else is present?

A aqueous silver nitrate and aqueous sodium nitrate
B aqueous sodium iodide and aqueous sodium nitrate
C aqueous sodium iodide only
D aqueous sodium nitrate only

15 Aqueous hydrogen peroxide, H_2O_2, decomposes slowly at 25°C.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The decomposition reaction takes place faster when a catalyst is added.

A student adds a small amount of catalyst to 10 cm^3 of 1.00 mol/dm^3 of aqueous hydrogen peroxide and collects the gas that is produced. The volume of gas collected is 90 cm^3. All measurements are made at room temperature and pressure.

What is the percentage yield of oxygen?

A 28.1% **B** 37.5% **C** 56.3% **D** 75.0%

16 What is a chemical product of a hydrogen-oxygen fuel cell?

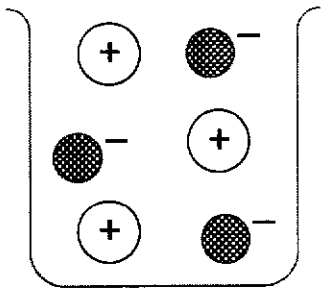
A electricity
B hydrogen
C oxygen
D water

17 Which method of preparation of magnesium sulfate is an example of redox reaction?

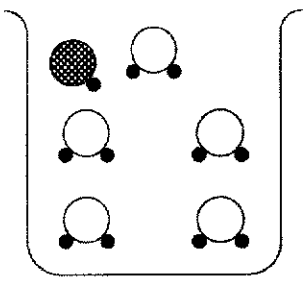
A $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$
B $MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$
C $Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$
D $MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + H_2O + CO_2$

18 Which diagram represents the ionisation of a weak acid?

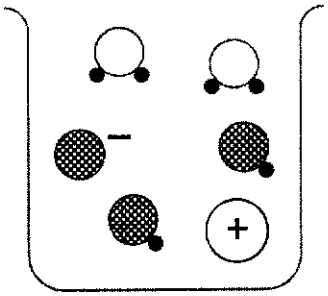
A



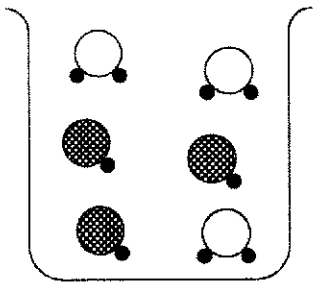
B



C



D



key:

 water molecule

 molecule of weak acid

 H^+ ion

 negative ion

19 A salt, H, dissolved in water to give a green solution. On adding chlorine, the green solution turned yellow. On addition of aqueous ammonia, the green solution gave a green precipitate and the yellow solution gave a red-brown precipitate. On addition of dilute nitric acid followed by aqueous barium nitrate, the green solution gave a white precipitate.

What is the formula of H?

A $CuCl_2$ **B** $CuSO_4$ **C** $FeCl_2$ **D** $FeSO_4$

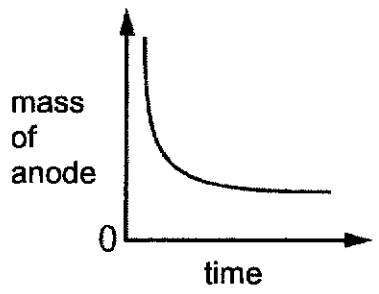
20 Which reaction shows the most suitable reaction for making silver chloride?

A $2Ag + 2HCl \rightarrow 2AgCl + H_2$
B $Ag_2CO_3 + 2HCl \rightarrow 2AgCl + CO_2 + H_2O$
C $AgNO_3 + HCl \rightarrow AgCl + HNO_3$
D $Ag_2O + 2HCl \rightarrow 2AgCl + H_2O$

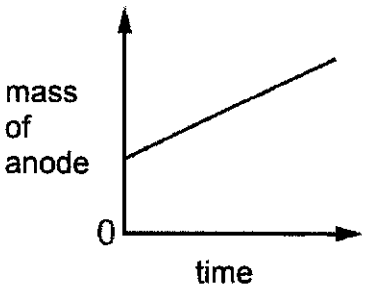
21 Aqueous copper(II) sulfate is electrolysed using copper electrodes. The current is constant and the anode is weighed at regular time intervals.

Which graph is obtained when the mass of the anode is plotted against time?

A



B



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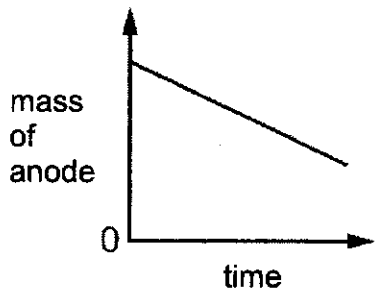

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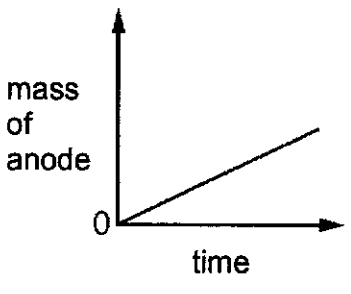


22 Which reagent and observation describes the test for a reducing agent?

	reagent	colour change
A	acidified aqueous potassium manganate(VII)	colourless to purple
B	acidified aqueous potassium manganate(VII)	purple to colourless
C	aqueous potassium iodide	colourless to purple
D	aqueous potassium iodide	purple to colourless

23 Electrolysis is used to plate a metal coin with silver.
The coin is used as an electrode in a suitable electrolyte.

Which row is correct?

	coin	electrolyte
A	anode	AgC*l*(aq)
B	anode	$AgNO_3$(aq)
C	cathode	AgC*l*(aq)
D	cathode	$AgNO_3$(aq)

24 Winkler method is used to determine the amount of dissolved oxygen in a water sample.
The procedure involves the following sequence of reactions.

Step 1 $2Mn^{2+}(aq) + O_2(g) + 4OH^-(aq) \rightarrow 2MnO(OH)_2(s)$

Step 2 $MnO(OH)_2(s) + 2I^-(aq) + 4H^+(aq) \rightarrow I_2(aq) + Mn^{2+}(aq) + 3H_2O(aq)$

Step 3 $I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

When a 5.00 dm^3 sample of water was analysed using the Winkler method, a total of 4.00×10^{-3} mol of thiosulfate ($S_2O_3^{2-}$) was required in Step 3.

What concentration of oxygen was present in the original sample?

A 3.20 mg/dm^3
B 6.40 mg/dm^3
C 12.8 mg/dm^3
D 32.0 mg/dm^3

25 Five statements about different elements are given.

1 proton number = 24
2 cuts easily with a knife
3 constituent of brass
4 burns in oxygen with a dazzling white light
5 catalyst in the Haber process

Which statement is correct for each element?

	K	Zn	Fe	Cr	Mg
A	2	3	4	5	1
B	2	3	5	1	4
C	3	2	5	1	4
D	4	5	2	3	1

26 The addition of calcium hydroxide to soil reduces its acidity but also reduces the efficiency of fertilisers.

Which **two** equations explain this?

1 $Ca(OH)_2(s) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$
2 $Ca(OH)_2(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + 2H_2O(l)$
3 $Ca(OH)_2(s) + 2NH_4NO_3(aq) \rightarrow Ca(NO_3)_2(aq) + 2NH_3(g) + 2H_2O(l)$
4 $Ca(OH)_2(s) + Cu^{2+}(aq) \rightarrow Cu(OH)_2(s) + Ca^{2+}(aq)$

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

27 Which statement is correct?

A Group 1 elements are less reactive than the Group 2 element in the same period because they only need to lose one electron to have complete shells.

B Group 1 elements are stored under oil to avoid reaction with oxygen and water in the air.

C Group 1 elements become more reactive as the group is descended because the number of outer shell electrons increases.

D The melting point of Group 1 elements decreases as the group is descended because there is more attraction between positive ions and the 'sea' of delocalised electrons.

28 Copper(II) carbonate, calcium carbonate and zinc carbonate decompose when heated.

What is the correct increasing order for their decomposition?

	lowest temperature ⟶ highest temperature		
A	calcium carbonate	zinc carbonate	copper(II) carbonate
B	copper(II) carbonate	calcium carbonate	zinc carbonate
C	copper(II) carbonate	zinc carbonate	calcium carbonate
D	zinc carbonate	copper(II) carbonate	calcium carbonate

29 Zinc is used to galvanise iron, which prevents the iron from rusting.

Which statements are correct?

1 The layer of zinc forms a barrier between the iron and the oxygen and water in the atmosphere.

2 Zinc will oxidise before the iron does, even if the layer of zinc is scratched.

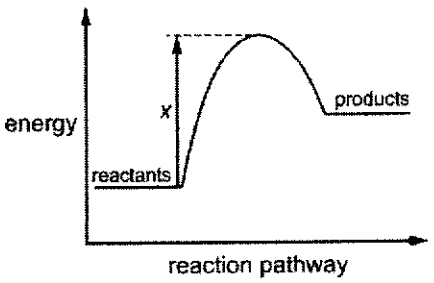
3 When iron rusts, atoms of iron gain electrons to form ions.

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

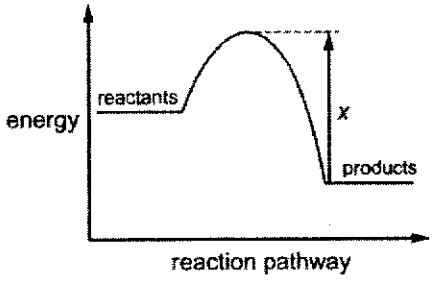
30 An endothermic reaction has an activation energy of *x*.

Which energy profile diagram is correct for this reaction?

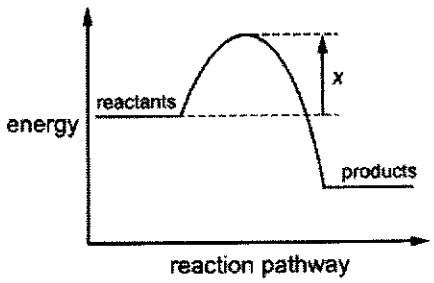
A



B



C



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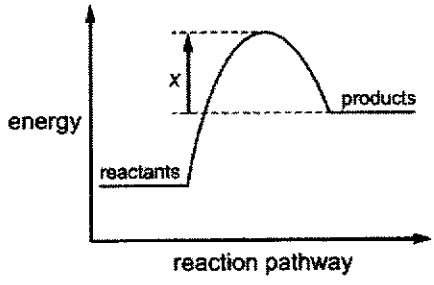


31 Two gases react inside a sealed vessel.

Which change in conditions would decrease the rate of reaction?

1 decreasing the pressure inside the vessel
2 decreasing the temperature inside the vessel
3 decreasing the volume of the vessel

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

32 The volume of gas produced by the reaction of 100 cm^3 of hydrochloric acid with an excess of calcium carbonate is measured in two experiments.

The volumes of gas are measured at room temperature and pressure, and the results are shown.

time / s	0	30	60	90	120	150	180	300
volume of gas in experiment 1 / cm^3	0	20	30	38	44	48	50	50
volume of gas in experiment 2 / cm^3	0	30	42	55	65	70	75	75

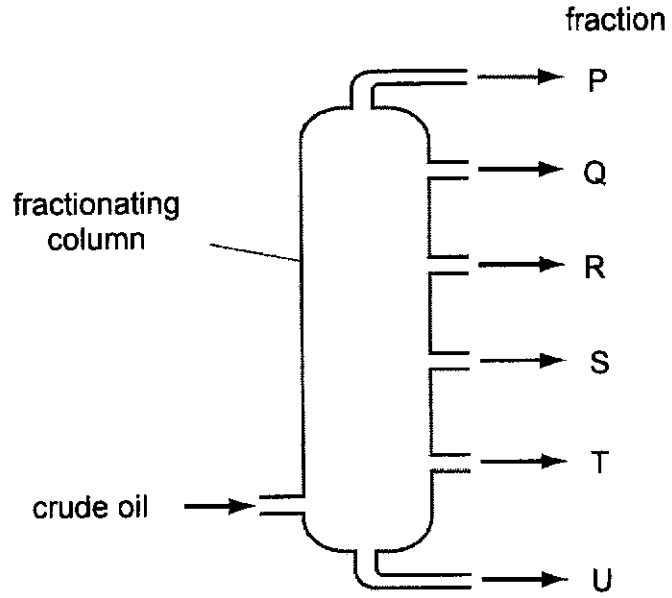
Which **one** change in conditions to experiment 1 gives the results for experiment 2? Assume all other conditions are unchanged.

A A greater mass of calcium carbonate is added.
B A higher concentration of acid is used.
C Smaller pieces of calcium carbonate are used.
D The temperature of the acid is higher.

33 Which statement about global warming is correct?

A Methane produced by digestion in animals has no effect on the rate of global warming.
B The products of burning fossil fuels have no effect on the rate of global warming.
C The products of decomposition of vegetation have no effect on the rate of global warming.
D The products of photosynthesis have no effect on the rate of global warming.

34 The diagram shows a fractionating column used in the separation of petroleum.



Which row explains why fraction R is collected above fraction S?

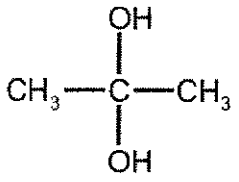
	boiling point of R	average molecular mass of R
A	greater than S	greater than S
B	greater than S	smaller than S
C	smaller than S	greater than S
D	smaller than S	smaller than S

35 Which statements about the cracking of hydrocarbons are correct?

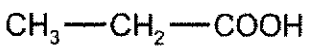
1 Cracking involves breaking down hydrocarbon molecules.
2 One of the products of cracking is always unsaturated.
3 Cracking is essential because of the demand for fractions containing smaller molecules.

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

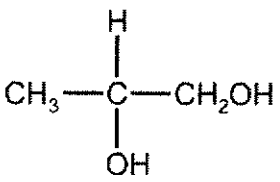
36 The structures of three compounds, W, X and Y, are shown.



W



X



Y

Which statements about these three compounds are correct?

1 W and Y are both alcohols and X is a carboxylic acid.
2 W, X and Y have the same molecular formula.
3 W and Y are structural isomers of each other.

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

37 Which equation shows the reaction of ethane with chlorine in the presence of ultraviolet light?

A $C_2H_6 + Cl_2 \rightarrow C_2H_6Cl_2$
B $C_2H_6 + Cl_2 \rightarrow C_2H_4Cl_2 + H_2$
C $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$
D $C_2H_6 + Cl_2 \rightarrow 2CH_3Cl$

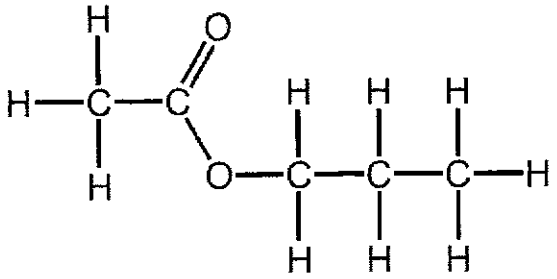
38 Isoprene is an alkene which is commonly found in plants.

Which properties does isoprene have?

1 It burns in air.
2 It can form condensation polymers.
3 It decolourises aqueous bromine.

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

39 The structure of an organic compound is shown.



Which **two** reactants form the organic compound?

A butanol and methanoic acid
B ethanol and propanoic acid
C propanol and ethanoic acid
D propanol and methanoic acid

40 Which compound, without the addition of any other reagent, polymerises to produce a polyamide similar to nylon?

A $C_2H_5CO_2H$
B $C_2H_5NH_2$
C $H_2N(CH_2)_4NH_2$
D $H_2N(CH_2)_4CO_2H$

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17

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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, $L = 6.02 \times 10^{23}\ mol^{-1}$.

O

ANDERSON SECONDARY SCHOOL
Preliminary Examination 2024
Secondary Four Express

CANDIDATE NAME:

CLASS: / INDEX NUMBER:

CHEMISTRY **6092/02**

Paper 2 **15 Aug 2024**

1 hour 45 minutes

0800 – 0945h

Candidates answer in the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.

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 26.

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

Section A	/70
Section B	/10
Total	/80

Setter: Mr Edmund Tan

Section A

Answer **all** questions.

1 **(a)** Use the list of substances to answer the questions.

You may use each substance once, more than once or not at all.

argon
carbon
carbon dioxide
chlorine
iron
iron(II) chloride
oxygen
neon

(i) Which **two** substances are diatomic gases at room temperature?

..... [1]

(ii) Which substance is a compound that contains a transition element?

..... [1]

(iii) Which substance provide an inert environment in light bulbs?

..... [1]

(iv) Which **two** substances form acidic oxides?

..... [1]

(v) Which **two** substances produce a solid when added to aqueous silver nitrate?

..... [1]

(b) Table 1.1 describes three processes.

Complete Table 1.1 by filling in the missing information.

Table 1.1

description of process	name of process
conversion of polyunsaturated fats to saturated fats	
formation of an organic compound by the reaction of alcohols and carboxylic acids	
mixing dilute hydrochloric acid and aqueous sodium hydroxide	

[3]

[Total: 8]

2 Mothballs, often used to repel moths and insects, gradually disappear over time when placed in a closed cupboard. A student places some mothballs in a closed cupboard and records its mass over several days. The following data was collected.

day	mass of mothballs/ g
0	5.0
2	4.6
4	4.2
6	3.8
8	3.4

During the experiment, no liquid or solution was found in the cupboard. A pungent gas was produced and can be detected whenever the cupboard doors are opened.

(a) Describe and explain the trend observed in the mass of the mothball over time.

.....

.....

..... [2]

(b) Explain how the concept of diffusion contributes to the observation of pungent smell.

.....

.....

..... [2]

[Total: 4]

3 Sustainable aviation fuels (SAFs) are being developed to reduce the carbon footprint of air travel. One method involves collecting used cooking oil from restaurants, processing it to remove impurities such as water and blending it with jet fuel. Fig. 3.1 shows the flow chart outlining the production process of SAFs.

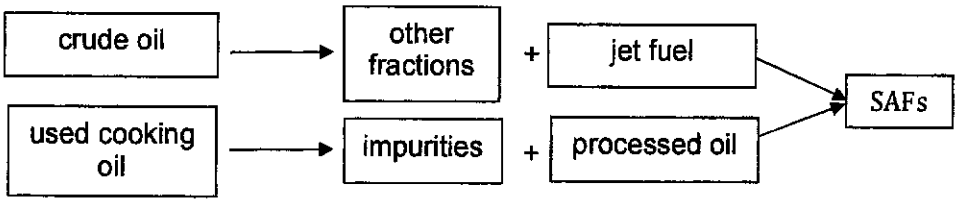


Fig 3.1

(a) (i) Name the separation process to obtain jet fuel from crude oil.

..... [1]

(ii) Explain how the named process in **(a)(i)** is used to separate different components of crude oil, including the fraction used as jet fuel.

.....

.....

.....

.....

..... [2]

(b) Describe how a separating funnel can be used to separate processed oil from impurities in used cooking oil.

.....

.....

.....

.....

..... [2]

(c) Biofuels, like sugarcane-based bioethanol, are alternative energy sources to fossil fuels.
Burning of bioethanol releases similar products as burning ethanol.

Discuss the concept of the carbon cycle and explain why the burning of bioethanol might **not** be always considered as carbon neutral.

.....

.....

.....

.....

.....

.....

..... [3]

(d) The equation describes the combustion of ethanol.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

Use the information to calculate the enthalpy change for this reaction.

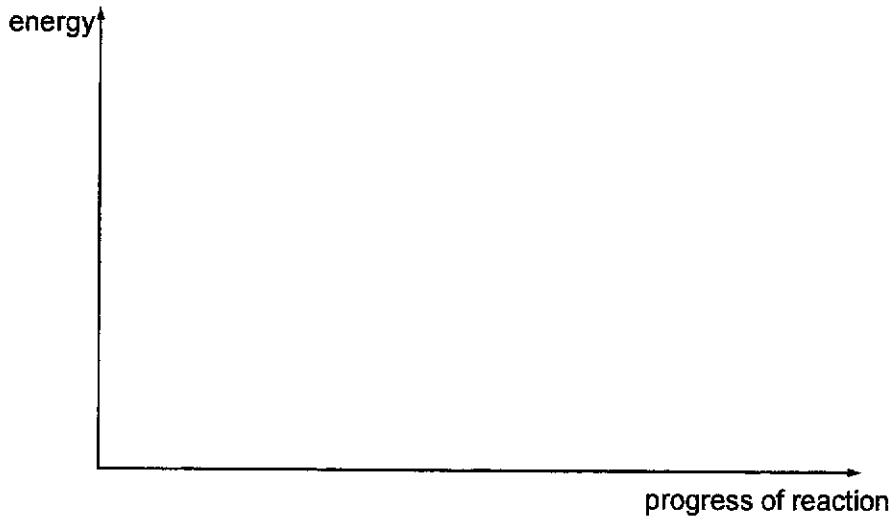
bond	bond energy kJ/mol	bond	bond energy kJ/mol
C–C	350	C=C	610
C–O	358	O=O	496
C–H	410	C=O	799
O–H	460		

enthalpy change = ... kJ [2]

(e) Complete the energy profile diagram for the combustion of ethanol.

Your diagram should include

- the formulae of reactants and products,
- the enthalpy change of reaction, and
- the activation energy.



[3]

[Total: 13]

4 Glutamic acid, an amino acid, is naturally present in the body and in many foods.

(a) Glutamic acid is a compound that contains 40.8% carbon, 6.1% hydrogen, 9.5% nitrogen and 43.6% oxygen by mass.

Determine the empirical formula of glutamic acid.
Show your working clearly.

[2]

(b) Monosodium glutamate, commonly known as MSG is the sodium salt of glutamic acid.

Deduce the charge on the glutamate ion.

..... [1]

(c) When amino acids undergo condensation polymerisation, they form a macromolecule.

Fig. 4.1 shows the repeat unit of a macromolecule formed by condensation polymerisation.

The repeat unit contains five different elements, C, O, N, H and X.

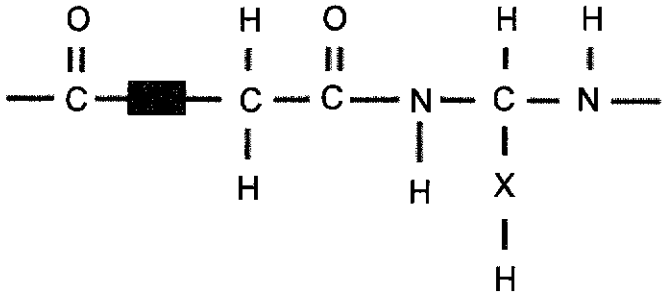


Fig. 4.1

(i) Name the type of linkage found in the repeat unit.

..... [1]

(ii) Draw the full structural formula of the **two** monomers.

[2]

(iii) Using ideas of valency, suggest an element that could be **X**.

..... [1]

(d) State the functional group that a molecule must have to undergo addition polymersiation.

..... [1]

[Total : 8]

5 **(a)** Lead is extracted by heating its oxide with hydrogen. The equation for the extraction is shown.

$$PbO + H_2 \rightarrow Pb + H_2O$$

Fig 5.1 shows the apparatus used for this extraction process.

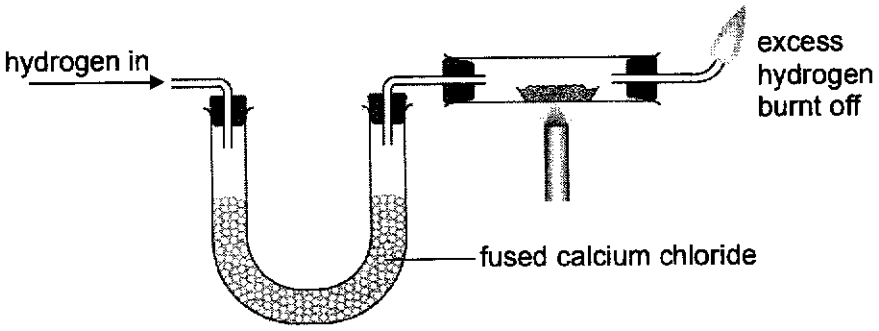


Fig 5.1

(i) Is hydrogen acting as the oxidising agent or reducing agent?

Explain your answer using the loss or gain of oxygen.

.....

..... [1]

(ii) "Aluminium can be extracted from its oxide using the same method."

Do you agree? Explain your answer.

.....

.....

..... [1]

(iii) After the heating has stopped, the flow of hydrogen gas must maintain until the solid has completely cooled to room temperature.

Explain why is this necessary.

.....

.....

.....

..... [2]

(b) (i) A disproportionation reaction is a reaction in which the same element is both oxidised and reduced, forming two separate products.
An example of a disproportionation reaction is shown.

$$4H_3PO_3 \rightarrow 3H_3PO_4 + PH_3$$

Explain, in terms of oxidation states, why the reaction is a disproportionation reaction.

.....

.....

.....

..... [2]

(ii) Comproportionation reactions also involve the oxidation and reduction of the same element.

An example of a comproportionation reaction involving sulfur is shown.

$$2H_2S + SO_2 \rightarrow 3S + 2H_2O$$

Use information in **(b)(i)** and **(ii)** to suggest how comproportionation reactions generally differ from disproportionation reactions.

.....

..... [1]

[Total: 7]

6 **(a)** The 'iodine clock' reaction is an experiment used to investigate rates of reaction.

In a series of experiments, aqueous potassium iodide was mixed with a fixed volume of starch and iron(III) salt solutions. The mixing produces iodine, which turns blue-black in the presence of starch.

The condition of each experiment varies, and these conditions affects the time taken for the solution to turn blue-black.

Table 6.1 shows the conditions and results for a series of experiments.

Table 6.1

experiment	volume of aqueous potassium iodide / cm^3	volume of distilled water / cm^3	temperature / °C	catalyst added	time taken for blue-black colour to appear/s
1	3.0	7.0	20	none	50
2	6.0	4.0	20	none	27
3	6.0	4.0	20	silver	26
4	6.0	4.0	20	copper	20
5	6.0	4.0	40	none	15

(i) Explain how a catalyst affects reaction rates.

.....

..... [1]

(ii) Using information in Table 6.1, compare the effectiveness of copper and silver as catalysts on the rate of reaction.

.....

.....

.....

..... [2]

(b) (i) Use ideas about collisions between particles, and with reference to values in Table 6.1, explain why changing the concentration and temperature affect the time taken for the blue-black colour to appear.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(ii) Explain the importance of starch in the experiments.

.....

.....

..... [2]

[Total: 9]

7 Sulfur dioxide, SO_2, is one of six pollutants that are closely tracked and monitored in the world. Emission sources include industries such as refineries and power stations, as well as motor vehicles and other sources.

The mass of SO_2 emissions over three decades is shown in Fig. 7.1.

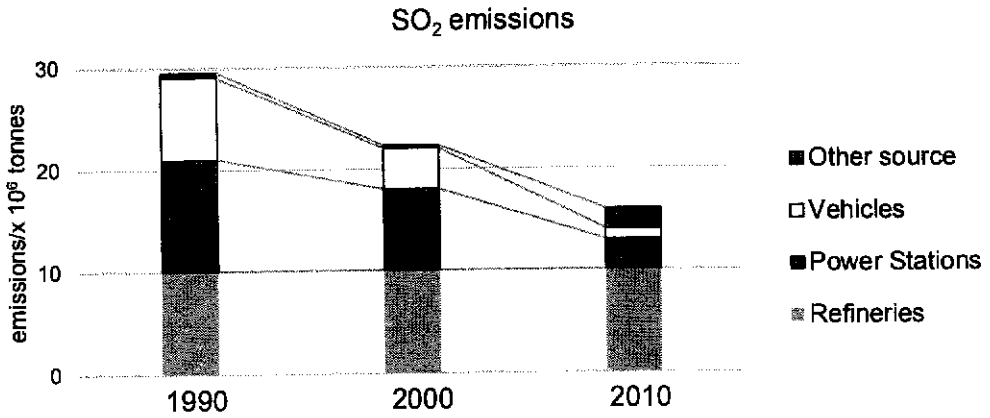


Fig. 7.1

(a) **(i)** Name the "other source".

..... [1]

(ii) Using Fig. 7.1, describe the trend in sulfur dioxide emissions for vehicles, power stations and refineries over three decades.

.....

.....

..... [1]

(b) Desulfurisation is a common method used to reduce SO_2 emissions in the industry. An example of a desulfurisation system, "wet scrubbing" in shown in Fig. 7.2.

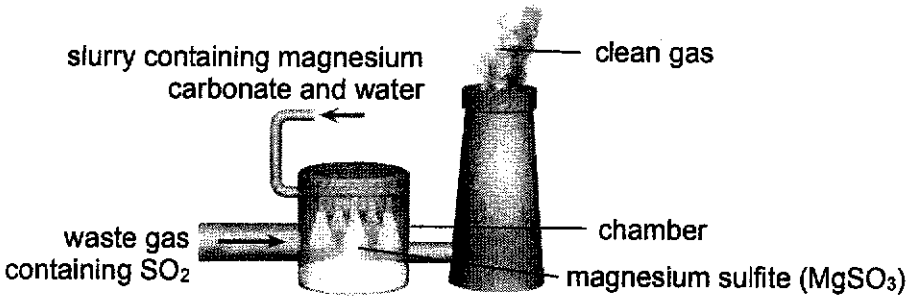


Fig. 7.2

In the wet scrubbing system, waste gas containing SO_2 is passed into the chamber. In the chamber, a slurry of magnesium carbonate and water is sprayed from the top.
The reaction produces a gas and magnesium sulfite which falls to the bottom of the chamber to be removed.

Complete the equation for the reaction that takes place during desulfurisation.

$SO_2(g)$ + [2]

(c) To increase the efficiency of SO_2 removal, a packed bed scrubber that contains beads can be installed in the chamber as shown in Fig. 7.3.

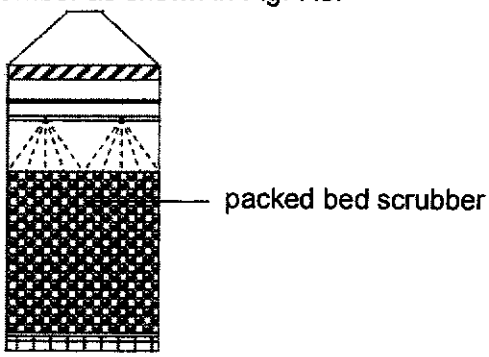


Fig. 7.3

(ii) Explain why installing the packed bed scrubber in the chamber is more efficient at removing SO_2.

.....

..... [1]

(iii) Explain why it is **not** feasible to install desulfurisation systems on vehicles.

.....

..... [1]

(c) In the desulfurisation of refinery exhaust gases, calcium carbonate can be used in place of magnesium carbonate in the wet scrubbing process. The prices of both substances are shown in Table 7.4

Table 7.4

substance	cost per kg/$
calcium carbonate	0.11
magnesium carbonate	0.14

Using information from this question, determine which substance will be **more cost efficient** for a refinery that emits 1280 kg of SO_2 per hour.
Show clear calculations in your answer.
You may assume that both carbonates have the same efficiency in removing SO_2.

[3]

[Total: 9]

8 The formation of covalent bonds can be described as a force of attraction between the positive nucleus of an atom and the valence electron of another atom.

Electronegativity

Covalent bonds are also affected by the electronegativity of the connected atoms, which determines the chemical polarity of the bond. Two atoms of equal electronegativity will make non-polar covalent bonds. The overlapping of electron orbitals will result in the dumbbell-like shape for molecules with non-polar covalent bonds as shown in Fig 8.1.

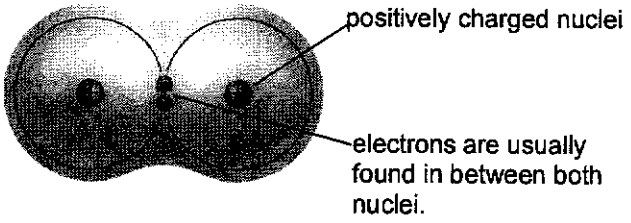


Fig 8.1

If the electronegativity difference is larger than 0.5, a polar covalent bond such as H–C*l* will be formed.

The unequal electronegativity between atoms causes a distortion in the shape and distribution of electron in the overlapping regions as shown in Fig 8.2.

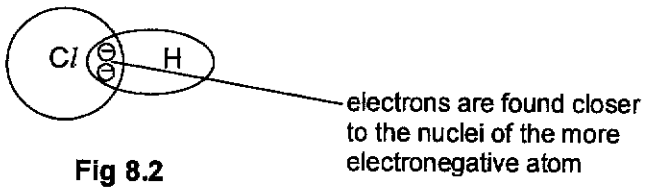


Fig 8.2

Due to the unequal distribution of electrons in the molecule, this creates a partial charge on each atom, where one is more 'positive' than the other.

The electronegativity of some elements is shown in Table 8.3.

Table 8.3

element	electronegativity	element	electronegativity
hydrogen	2.20	sodium	0.93
carbon	2.55	fluorine	3.98
nitrogen	3.04	chlorine	3.16
oxygen	3.44	bromine	2.96

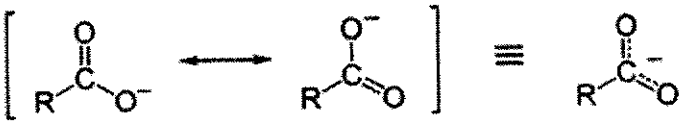
Effect of electronegativity on the stability of carboxylate anions

(resonance structure of carboxylate anions)

A molecule of carboxylic acid dissociates into a carboxylate anion and a hydrogen ion.

$$R\text{–}COOH \rightarrow RCOO^- \text{ and } H^+$$

Where **R** represents an organic group.



carboxylate anions resonance structure

The negative charge on the ion after dissociation of the H^+ ion is delocalised between the two electronegative oxygen atoms in a resonance structure. The stability of the resonance structure is dependent on the **R** group's ability to either, facilitate or hinder electron flow to the oxygen atoms.

If the **R** group is an electron-donating group, the negative charge on the resonance structure will be strengthened. The resonance structure would then strongly attract any nearby H^+ ions and form the acid molecule again.

If the **R** group is an electron-withdrawing group (containing electronegative atoms), the negative charge on the resonance structure will be weakened.

Dissociation constant of organic acids.

The dissociation constant of an organic acid indicates the extent to which it dissociates into ions. The larger the dissociation constant, the higher the extent of dissociation. The dissociation constant varies with different **R** groups. The names of the organic acid together with their dissociation constant values is shown in Table 8.4.

Table 8.4

R group	dissociation constant	name of acid
$-CH_3$	1.75×10^{-5}	ethanoic acid
$-CH_2CH_3$	1.34×10^{-5}	propanoic acid
$-CH_2Cl$	1.40×10^{-3}	chloroethanoic acid
$-CHCl_2$	4.50×10^{-2}	dichloroethanoic acid
$-CH_2Br$	1.30×10^{-3}	bromoethanoic acid
$-CH_2F$	2.60×10^{-3}	fluoroethanoic acid

Data retrieved from :
https://chem.libretexts.org/Ancillary_Materials/Reference/Reference_Tables/Equilibrium_Constants/E1%3A_Acid_Dissociation_Constants_at_25C

(a) (i) Complete the table for the missing information.

name of substance	chemical formula	type of covalent bond(s) present (tick one)		
		polar	non-polar	not applicable
hydrogen chloride	HCl	✓		
sodium fluoride				
	CH_4			
	O_3			

[3]

(ii) Using information from Table 8.3, describe the trend in electronegativity across period 2 and down group 17.

.....

.....

.....

..... [2]

(b) (i) What is the impact of electron-donating groups on the pH of the acid?

.....

.....

.....

.....

..... [2]

(ii) Draw a 'dot-and-cross' diagram to show the arrangement of electrons in a carboxylate ion. You may replace the R group with a hydrogen atom.

Show outer electrons only.

[2]

(c) (i) Using information from Table 8.4, draw the full structural formula of dichloroethanoic acid.

[1]

(ii) State the characteristics of a stronger organic acid.

Explain your answer in terms of electronegativity and quantitative data.

.....

.....

.....

..... [2]

[Total: 12]

21

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Section B

Answer **one** question from this section.

9 Fig 9.1 shows the electrolysis of a solution containing Na^+ and Cl^- ions after x minutes.

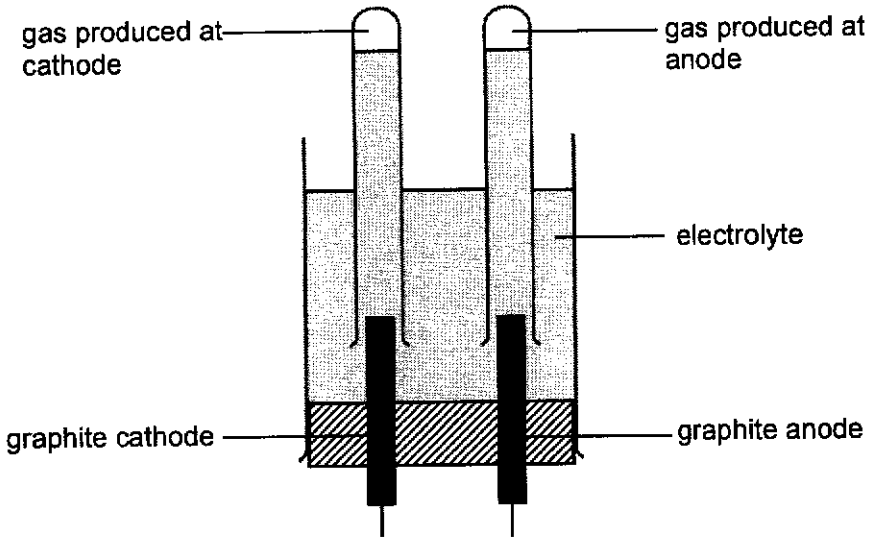


Fig 9.1

(a) Use information from the fig 9.1 to name the electrolyte.

.....[1]

(b) Write ionic equations for the reactions at the cathode and anode.

cathode .....

anode ..... [2]

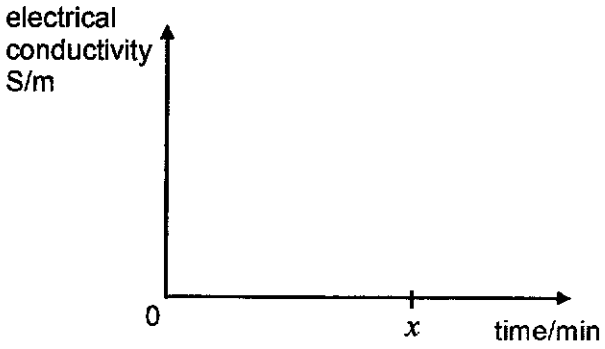
(c) Describe a positive test for the gas produced at the cathode.

.....

.....[1]

(d) A data logger can be used to monitor the electrical conductivity of the electrolyte over time.
The higher the concentration of ions in the electrolyte, the higher the electrical conductivity of the solution.

(i) Sketch the graph in the axes below to show how the electrical conductivity changes from 0 min to x min.



[1]

(ii) Explain the shape of your graph in **(d)(i)**.

.....

.....

..... [2]

(e) The above electrolysis is repeated using platinum cathode and silver anode. Only the anode had a different observation.

(i) Explain why the same observation was recorded at both the graphite cathode and platinum cathode.

.....

..... [1]

(ii) Describe and explain the observation at the silver anode.

.....

.....

.....

..... [2]

[Total : 10]

10 Fig 10.1 shows a setup where the bulb lights up, indicating a closed circuit.
A gas is produced at one of the electrodes.

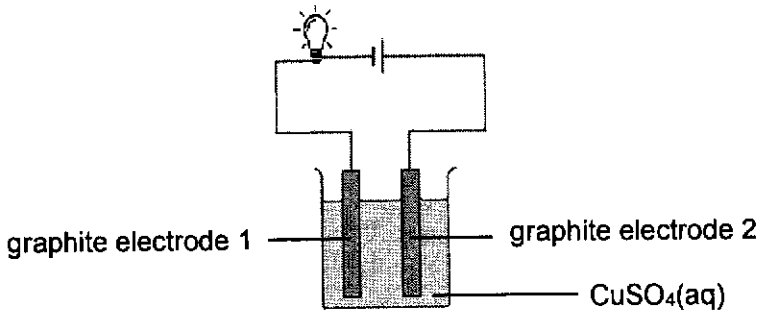


Fig 10.1

(a) Explain, in terms of bonding, how the graphite electrodes enable the setup to be a closed circuit.

.....

.....

.....

..... [2]

(b) Name the product that forms at each electrode.

graphite electrode 1 .....

graphite electrode 2 ..... [2]

(c) Describe a test for the gas produced.

test .....

observation ..... [1]

(d) In another experiment, the light intensity of the bulb was measured when different electrodes, graphite, W, X, Y and Z were used.
Metal W is the most reactive metal out of the four unknown metals.

The results were recorded and shown in Table 10.2.

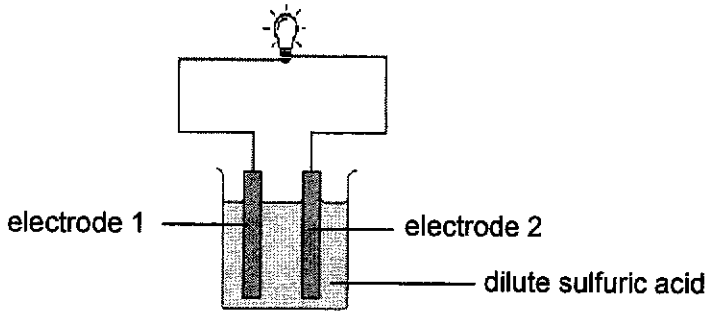


Table 10.2

experiment	electrode		light intensity/units
	1	2	
1	graphite	W	bulb did not light up
2	W	W	bulb did not light up
3	W	X	1.0
4	Y	X	0.3
5	Z	Y	0.1
6	Z	W	0.6

(i) Explain why the bulb did **not** light up for experiments 1 and 2.

.....

.....

..... [2]

(ii) Arrange the metals W, X, Y and Z in order of increasing reactivity.

..... [1]

(iii) When lead was used as an electrode, the bulb lights up briefly and stops after some time. Explain this observation.

.....

..... [2]

[Total: 10]

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 Sec 4E Chemistry Preliminary Examination – Answer Scheme

Paper 1

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

EXAM ANSWERS

Year:	**2024**
Exam:	**Prelim**
Level/Stream:	**4E**
Subject:	Chemistry **6092**

P2

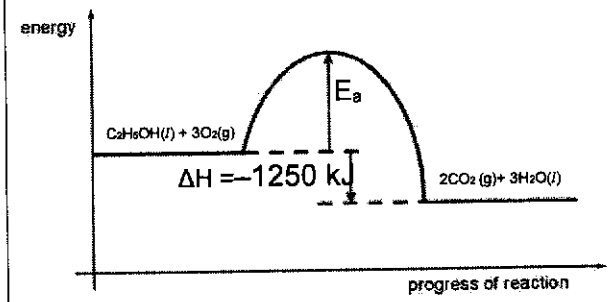
Qn	Answer	Marks	Comments
1 a i ii iii iv v	 chlorine **and** oxygen iron(II) chloride argon carbon **and** chlorine iron **and** iron(II) chloride	5	**1m each**
A1 b	Addition reaction with hydrogen ACCEPT: Hydrogenation / Addition with Hydrogen / addition of H_2 Esterification Neutralisation ACCEPT: neutralization REJECT: acid-alkali reaction	3	1m each

Qn	Answer	Marks	Comments
2a	The **mass** of the mothballs decrease / becomes smaller over time. REJECTED: Mothballs become smaller / reduce in size / shrink. This indicates that the mothball is gradually disappearing, which can be explained by sublimation, where the mothball turns from a solid into a gas without going though the liquid state. ACCEPT: sublimation / solid sublimes to form gas / solid particles gain sufficient energy to overcome forces of attraction and become gas/gaseous particles. REJECT: decomposition	2	1 - trend 1 - reason

2b	Diffusion is the movement of gas molecules from a region of higher concentration near the mothballs to a region of lower concentration throughout the cupboard. As the molecules are spread out and mixed with the air molecules, the pungent smell can be observed. / Gas molecules (of mothball) collide/ mix with molecules in the air and spread across the room/space. REJECTED: travel / move	1 1	1m – diffusion definition on solute movement 1m- mixing with air molecules

Qn	Answer	Marks	Comments
3a i	Fractional distillation REJECTED: distillation, fractionating distillation	1	
3a ii	In the furnace, the crude oil is heated into a vapour / heated and vapourise before it enters the fractionating column. The vapour contains a mixture of hydrocarbons with different boiling points. As the vapour rises up the column, the fractions with lower boiling points rise further up the column and condense at a lower temperature while the fractions with higher boiling points condense at a higher temperatures and collect at the lower part of the column. / As the vapour rises up the column, the fractions with higher boiling points condense and are collected at lower down the column while the fractions with lower boiling points rise further up the column to be collected. Jet fuel is collected as one of the fractions.	1 1	
3b	Used cooking oil contains impurities such as water. As the used cooking oil is placed in the separating funnel, the mixture separates into different layers based on density differences. When allowed to settle, the liquid that is denser can be tapped off from the bottom, the remaining layer will be the processed oil. (OWTTE)	1 1	Qn stated water as impurities; water is denser than cooking oil and settles at the bottom layer.

3c	Carbon dioxide is released/produced/given out during the burning/combustion of bioethanol, while bioethanol produced by the sugarcane plants which absorb/take in carbon dioxide during photosynthesis. This does not increase the net amount of CO_2 in the surroundings. **OR** The amount of carbon dioxide released/produced/ given out from the burning/combustion of bioethanol **is offset** by the amount of carbon dioxide absorb/take in carbon dioxide during photosynthesis of the sugar cane plant. However, other processes such clearing of land for sugarcane crops and burning of fossil fuels during farming or transporting of sugarcane would releases even more carbon dioxide, making the use of bioethanol less sustainable.	1 1 **OR** 2 1	Key processes AND CO_2 produced/absorbed. Carbon neutral Other processes (related to making of bioethanol) that release CO_2
3c	Overall enthalpy change = Total energy absorbed during bond-breaking in reactants – Total energy released during bond-forming in products = [350 + 5(410) + 358 + 460 + 3(496)] – [2 x 2(799) + 3 x 2(460)] = 4706 – 5956 = –1250 kJ CAP 1 mark for "1250 kJ"	2	1m – for suitable working, correct number of bonds 1m – for correct answer
3d		3	1m – correct shape (exothermic) with reactants and products labelled with (state symbols)



CAP 1 mark for E_a if wrong shape of profile diagram is drawn.

ECF wrong ΔH calculated from (c) if ΔH is negative.

REJECT: positive ΔH, double-head arrows, 'floating' arrows

IGNORE: miss enthalpy value (i.e. - 1250 kJ), eqn which is not balance

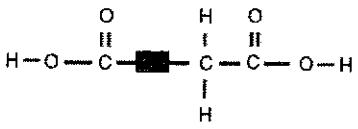
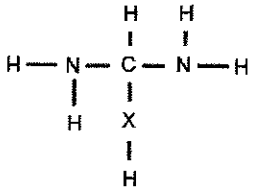
1m – E_a labelled

1m – ΔH with values labelled (value ECF)

Qn	Answer	Marks	Comments
4 a	Assume 100g of compound. IGNORE if missing.		

	C	H	N	O
Mass	40.8	6.1	9.5	43.6
A_r	12	1	14	16
Mole	$\frac{40.8}{12} = 3.4$	$\frac{6.1}{1} = 6.1$	$\frac{9.5}{14} = 0.6786$	$\frac{43.6}{16} = 2.725$
Divide by smallest no	3.4/0.6786 = 5.0106	6.1/0.6786 = 8.9895	0.6786/0.6786 =1	2.725/0.6786 = 4.0158
Simplest ratio	5	9	1	4

		1	Working for calculation of moles
	$C_5H_9NO_4$ ACCEPTED any order of elements.	1	correct empirical formula
4b	– / -1 / 1- / minus 1 / negative 1	1	

4c i	Amide linkage	1	
4 c ii	 Monomer 1 IGNORE unshaded box (marker will annotate for student, teacher please remind)  Monomer 2	2	
4 c iii	Sulfur REJECT: oxygen (question stated five different elements)	1	
4 d	C=C bond / carbon-carbon double bond REJECTED: double C=C bond, double carbon bond.	1	

Qn	Answer	Marks	Comments
5 a i	Reducing agent, hydrogen has removed oxygen atoms from PbO to form Pb. ACCEPTED: Hydrogen takes/took away oxygen; PbO lost oxygen to hydrogen to form Pb; Hydrogen caused PbO to lose oxygen and formed Pb and itself is oxidized. REJECTED: Lead/Pb lost its oxygen from PbO to Pb	1	
5 a ii	No, aluminium is more reactive than hydrogen / aluminium is a reactive metal that is placed above hydrogen in the reactivity series / hydrogen is less reactive than aluminium and cannot displace aluminium form its ore. It can only be extracted by electrolysis of its molten oxide. REJECTED: Aluminium is more reactive than iron (note that this does not answer to the context).	1	

5 a iii	After the heating has stopped, the extracted lead metal is still very hot. With the constant flow of hydrogen gas, it prevent the oxygen from the surrounding air form reacting with hot lead metal to form lead(II) oxide. Propose CAP 1 mark for To ensure complete reduction (of lead(II) oxide) / to ensure all lead(II) oxide fully reduced to lead. REJECTED: to prevent hydrogen from reacting with oxygen in the air; to avoid hydrogen from combusting with oxygen/air.	1 1	
5 b i	H_3PO_3 is oxidised because the oxidation state of phosphorus increases from +3 in H_3PO_3 to +5 in H_3PO_4. H_3PO_3 is also reduced because the oxidation state of phosphorus decreases from +3 in H_3PO_3 −3 in PH_3. CAP 1 mark for correct oxidation states of phosphorus in all compounds but did not specify oxidized / reduced with respect to increase / decrease of oxidation states.	1 1	
5b ii	Comproposition reaction is a reaction in which the same element in two different reactants is both oxidised and reduced, forming one/a (single) product containing the element. Or OWTTE e.g. Comproposition reaction involves two different reactant containing the same element undergoing redox reaction / reduction and oxidation to form a/one product containing that element.	1	

Qn	Answer	Marks	Comments
6 a i	By providing an alternative pathway of lower activation energy to speed up / increase / fasten the rate of reaction.	1	
6 a ii	Comparing experiments 2, 3 and 4. When copper catalyst is used, reaction time decreased by 7 seconds, hence faster rate of reaction. Copper is an	1	use data to compare time

	effective catalyst. But silver catalyst reduced time by 1s, reduction of time is not significant/not acting as a catalyst/not an effective catalyst. CAP 1M when effectiveness of Silver as a catalyst is not mentioned	1	conclusion of effective and not effective
6 b i	**Concentration** • In experiment 1 and 2, doubling the concentration of aqueous potassium iodide solution, increases the number of reacting particles per unit volume, hence increasing the total number of collisions between particles. **Temperature** • In experiment 2 and 5, increasing the temperature increases the kinetic energy of the reacting particles and hence, more particles possess energy equal to or greater than the activation energy for reaction. • In both cases, the frequency of effective collisions between reacting particles increases and hence, rate of reaction (rate of formation of iodine) increases. • Therefore, the time taken for the blue black colour to appear decreases. CAP 2 marks if data from question, experiment numbers and time/decrease in time are not quoted.	1 1 1 1	Explain effect of ↑ conc on no. of reacting particles Explain effect of ↑ temp on energy of reacting particles Link both to increased frequency of effective collision Relate to time taken to ↓
6 b ii	The iodine produced dissolves in the solution to produce a brown solution. The experiment involves iron(III) solutions, which is brown. The end point cannot be determined as I_2 in solution is also brown hence the reaction between iodine and starch to turn the solution blue black will help determine the end point of the reaction. CAP 1m for students who can link to starch being an **indicator** to signal formation of iodine	1 1	

<table>
<tr><th>Qn</th><th>Answer</th><th>Marks</th><th>Comments</th></tr>
<tr><td>7ai</td><td>Volcano / volcanic <u>eruptions/activities.</u></td><td>1</td><td></td></tr>
<tr><td>7aii</td><td>Sulfur dioxide emissions from vehicles and power stations decreased while emissions from refineries remained constant.

REJ : total emission decreased</td><td>1</td><td></td></tr>
<tr><td>7bi</td><td>SO_2 (g) + $MgCO_3$ (s) → $MgSO_3$ (s) + CO_2 (g)

IGNORE: water (in whichever state)
$SO_2(g) + MgCO_3(s) + \cancel{H_2O(l)} \rightarrow MgSO_3(s) + CO_2(g) + \cancel{H_2O(l)}$
Exception of water on reactant but not products (equation is not balanced)
i.e.
$SO_2(g) + MgCO_3(s) + H_2O(l) \rightarrow MgSO_3(s) + CO_2(g)$</td><td>2</td><td>1m formula
1m state symbol</td></tr>
<tr><td>7b ii</td><td>The beads in the packed bed allows <u>a larger / greater / more / bigger surface area</u> for the reaction/scrubbing to take place. Hence, more SO_2 can be removed.</td><td>1</td><td></td></tr>
<tr><td>7b iii</td><td>The system is <u>too big / bulky / costly</u> to be fitted on cars.

ACCEPT: not portable, not practical to replace magnesium sulfite</td><td>1</td><td>Mentioned in TB</td></tr>
<tr><td>7c</td><td>Mole of $SO_2 = \frac{1\,280\,000}{64} = 20\,000$mol
Mole ratio 1: 1
<table>
<tr><th></th><th>Moles required</th><th>M_r</th><th>Mass/g</th><th>Cost</th></tr>
<tr><td>$CaCO_3$</td><td>20 000 mol</td><td>100</td><td>2 000 000</td><td>$\frac{2\,000\,000}{1000} \times 0.11$
= $220.00</td></tr>
<tr><td>$MgCO_3$</td><td>20 000 mol</td><td>84</td><td>1 680 000</td><td>$\frac{1\,680\,000}{1000} \times 0.14$
= $235.20</td></tr>
</table>
Using calcium carbonate is cheaper.

ACCEPT alternative methods:
Comparison by cost per mole of substance
Comparison by amount of substance (mole) for a fixed cost.

REJECT: method that compares mass (in kg or g) for fixed cost or vice versa.</td><td>1

1

1</td><td>1m – relating mole of SO_2 to mole of carbonate required.

1m evaluating cost for mass of respective carbonates and making conclusion.

1m – Presentation "showing clear calculations"</td></tr>
</table>

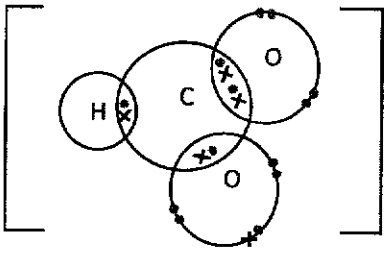
<table>
<tr><th>Qn</th><th>Answer</th><th>Marks</th><th>Comments</th></tr>
<tr><td>8a i</td><td>
<table>
<tr><th rowspan="2">name of substance</th><th rowspan="2">chemical formula</th><th colspan="3">type of covalent bond(s) present</th></tr>
<tr><th>polar</th><th>non-polar</th><th>not applicable</th></tr>
<tr><td>hydrogen chloride</td><td>HCl</td><td>✓</td><td></td><td></td></tr>
<tr><td>sodium fluoride</td><td>NaF</td><td></td><td></td><td>✓</td></tr>
<tr><td>methane</td><td>CH_4</td><td></td><td>✓</td><td></td></tr>
<tr><td>ozone</td><td>O_3</td><td></td><td>✓</td><td></td></tr>
</table>
</td><td>3</td><td>3m – 6 correct
2m – 4 or 5 correct
1m – 2 or 3 correct.</td></tr>
<tr><td>8a ii</td><td>Across period 2, from <u>carbon to fluorine</u> the electronegativity increases from <u>2.55 – 3.98</u>.
Down group 17, from <u>fluorine to bromine</u>, the electronegativity decreases from <u>3.98 – 2.96</u>.

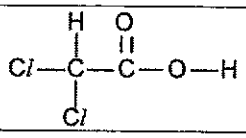
IGNORE: MISSING values in answer i.e. don't undermine the numbers.

IGNORE: missed out fluorine when describing period 2.</td><td>1

1</td><td></td></tr>
<tr><td>8bi</td><td>pH of acid <u>increases</u> as <u>concentration/amount of hydrogen ions per unit volume decreases</u>

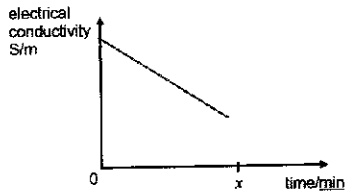
due to the presence of electron-donating group which causes <u>formation/reformation of acid molecules</u> and hence <u>reduced/decreased the (extent) of ionisations/dissociation (of acid)</u>.</td><td>1

1</td><td>Just stating pH increase/decrease → no marks awarded (probability 0.5)</td></tr>
<tr><td>8bii</td><td> 
</td><td>2</td><td>1m – correct conversion of structural formula to electrons (including the negative charge)

1m – duplet/octet (including extra electron on O)</td></tr>
<tr><td>8ci</td><td>  </td><td>1</td><td></td></tr>
</table>

8cii	*Chloroethanoic acid / bromoethanoic acid / fluoroethanoic acid has a <u>higher</u> dissociation constant (of ... *value from the table*) than ethanoic acid. This shows that the <u>presence of halogen / an electronegative atom</u> in the R group which is electron-withdrawing. *comparison of dissociation constant of any two organic acid	1 1	

Section B

Qn	Answer	Marks	Comments
9a	<u>Concentrated</u> sodium chloride solution ACCEPTED: <u>concentrated</u> aqueous sodium chloride REJECTED: saturated	1	
9b	Cathode : $2H^+(aq) + 2e^- \rightarrow H_2(g)$ Anode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ Max 1m if student mixed up cathode and anode half equation. (No ecf for test for chlorine gas) Allow ECF for anode if candidate answered aqueous/dilute NaCl in **(a)**, **i.e.** $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$	1 1	
9c	Insert a lighted splint into the gas. Gas extinguishes lighted splint with a 'pop' sound. **ACCEPT** pop, "pop", 'pop', gas gives "pop" sound with lighted splint. Allow ECF for correct test for wrong gas identified in **(b)**	1	
9d i		1	<u>Decreasing</u> line or curve Does not touch 0 (imply that ions are still present)

9d ii	As electrolysis proceeds, ions are discharged at the electrodes, this decreases the number of ions per unit volume/concentration of ions. Hence, electrical conductivity decreases.	1 1	discharge of ions idea of concentration
9 e i	Platinum, like graphite, is an inert electrode.	1	
9 e ii	The silver electrode/anode becomes smaller/reduced in size/ shrink over time. Reactive silver electrode loses electrons/is oxidise/undergoes oxidation and forms silver ions in the electrolyte. OR White precipitate is formed in the electrolyte over time. The silver electrode/anode loses electrons/is oxidise/undergoes oxidation to form silver ions which react/combined with chloride ions in the electrolyte to produce insoluble silver chloride. REJ: silver is lower than hydrogen in the reactivity series. The focus of this question is on silver being a reactive electrode. Silver is not an inert electrode (do not use reverse argument), just say that silver is a reactive electrode.	1 1 **OR** 1 1	Observation Explanation

Qn	Answer	Marks	Comments
10 a	In graphite, each carbon atom is bonded to only three other carbon atoms, thus each carbon atom has a valence electron that is not bonded and delocalised. These electrons can act as mobile charge carrier to conduct electricity, hence the circuit is closed. **CAP 1m for** - presence of delocalised / free-moving / mobile electrons if student did not or poorly elaborate on the structure of graphite.	1 1	Explain 1 electron per carbon atom Mobile charge carrier
10 b	Copper Oxygen	1 1	
10 c	Insert a glowing splint into the gas. The gas relights a glowing splint.	1	

	Allow ECF for correct test for wrong gas identified in **(b)**		
10 d i	When two different metals are put together, the difference in their reactivity causes the movement of electrons, which enables the bulb to be lighted up. In experiment I, graphite is inert and does not take part in any reaction. In experiment II, both electrodes are made of the same metal/ has no difference in the reactivity. There is no movement of electrons, hence bulb did not light up. **OR** In experiment 1, graphite is an inert electrode / is not a metal. In experiment 2, the two metal electrodes are the same and hence there is no potential difference / no difference in the reactivity. REJECT: There is no difference in reactivity between graphite and W. Should not use reverse argument i.e. The two electrodes are not different.	1 1 **OR** 1 1	1m Understanding simple cell, chemical reactions, electron movement caused by different reactivities. 1m Inert, and same metal
10 d ii	X, Y, Z, W	1	
10 d iii	Lead reacts with dilute sulfuric acid to form a layer of insoluble lead(II) sulfate around the surface of the lead electrode. As the electrode is no longer a conductor of electricity, the (discharging of ions is unable to take place), the circuit breaks and the bulb does not light up anymore. REJECT: prevent further reaction → Need to elaborate on what is prevented.	1 1	