A – Z School's Preliminary Papers
4 Express
Chemistry

ANSWERS: Part 4

P	Paya Lebar Methodist Girls' School
Q	Queensway Secondary School
R	Riverside Secondary School
S	Singapore Chinese Girls' School.
T	Temasek Secondary School

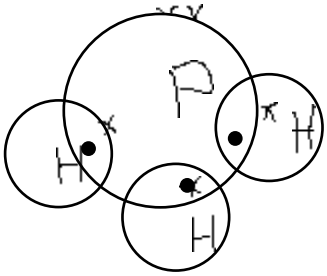
PAYA LEBAR METHODIST GIRLS' SCHOOL

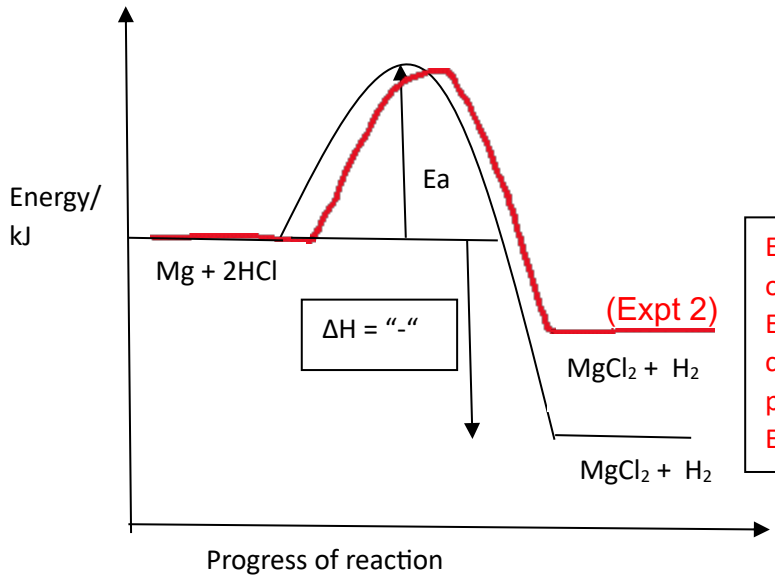
Paper 1

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

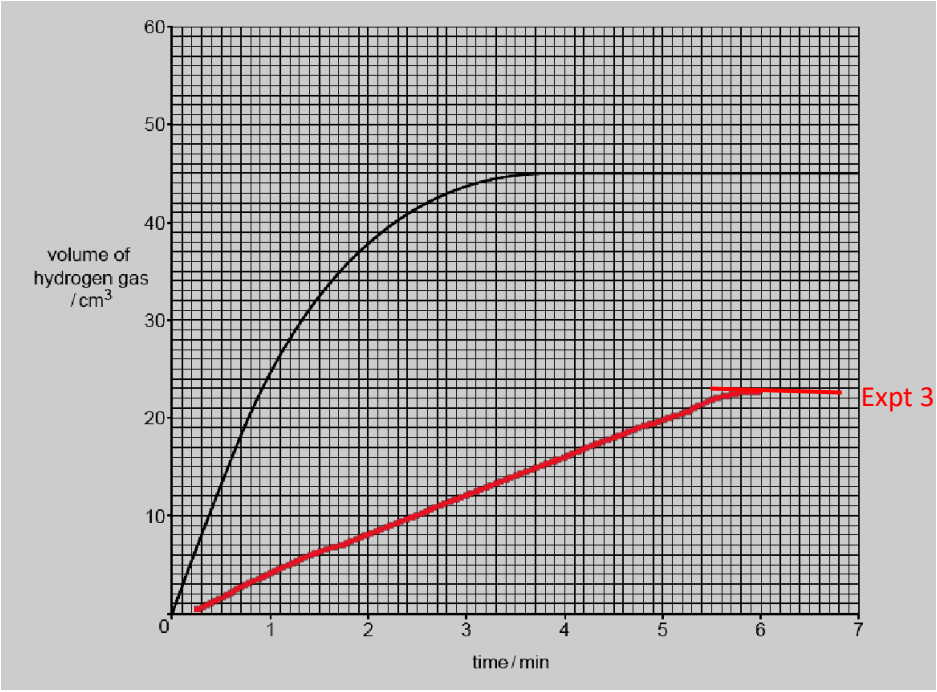
Paper 2

A1(a)	Cu, Fe (must give both to score 1m)(accept if students write name)	[1]
(b)	Mg	[1]
(c)	H_2 (Al accepted as $AlCl_3$ is covalent- students may not know)	[1]
(d)	Cu or Fe	[1]
(e)	Fe	[1]
A2 (a)(i)	Accept any value from 6.00 to 9.00 *<u>Marker's Comments</u>: Units are required (several students did not write the units). However, students were not penalised for not writing units.*	[1]
(a)(ii)	There is no trend in the mpt of the Group V elements	[1]
(b)(i)	Compound R is an <u>ionic</u> compound with a <u>giant crystal lattice structure</u> and the <u>strong electrostatic forces of attraction between the Na^+ and P^{3-} ions</u> (or oppositely charged ions) require <u>lots of energy to overcome</u>, hence high melting point.	[1] [1]

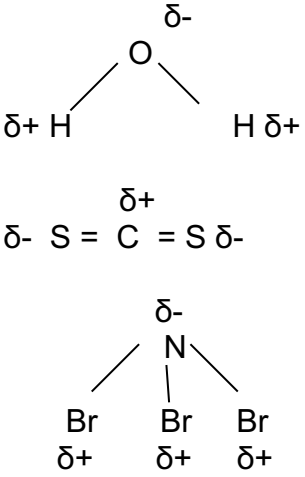
	Compound S is a covalent compound with <u>simple molecular structure.</u> The <u>weak intermolecular forces of attraction between the molecules require little energy to overcome (or easily overcome),</u> hence low melting point. <u>*Marker's comments*</u> *Question says structure and bonding, hence students are required to specify* ***ionic*** *bonding AND* ***giant crystal lattice structure (****however, 1 m was given if students stated either ionic or giant crystal lattice structure****) ;* ***covalent*** *compound AND* ***simple molecular structure.*** *For compound R: Students are required to specify the Na^+ and P^{3-} ions (or oppositely charged ions)-answer according to the question! The qn says <u>high</u> mpt, so it is not a comparison with compound S, hence "lots of energy to overcome" and NOT more energy is required.* *For compound S: The qn says <u>low</u> mpt, so it is not a comparison with compound R, hence "little energy overcome" and NOT lesser energy is required.*	[1] [1]
(b)(ii)	 [1]- correct no of electrons for P [1]-correct no of electrons shared with 3 H	[1] [1]
(c)(i)	Mr of P_4O_{10} = (31 x 4) + (16 x10) = 284 % of P = (31 x 4) /284 x 100% = 43.7% (3sf) <u>*Marker's comments*</u> *Mr has no units. If students write units, they will be penalised.*	[1] [1]
(ii)	Oxidation state of S in Compound S = -3 P_4O_{10} = +5	 [1] [1]
A3 (a)	To prevent the iron from reacting with the <u>oxygen</u> in the air/being oxidised. <u>*Marker's comments*</u> *Several students thought it was to ensure the reaction was complete. Do remember most hot metals will react with oxygen in the air!*	[1]

	It is required to write "oxygen" and not any gas(other gases) in air as this is a specific reaction- oxidation.	
(b)(i)	Mass of iron = 56.04 – 51.56 = 4.48 g Mass of chlorine = 64.56 – 56.04 =8.52 g	[1] [1]
(b)(ii)	No of moles of iron = 4.48/56 =0.0800 mol No of moles of chlorine = 8.52/35.5 =0.2400 mol Mole ratio of no of moles of iron: no of moles of chlorine **atoms** = 0.0800: 0.240 = 1: 3 *Marker's comments:* *Common mistake was to calculate and compare the no of moles of chlorine gas instead of chlorine **atoms**. From the ratio, the formula of the iron chloride compound is derived, which students need to write the balanced chemical equation in (iii).* [1]- for both Fe & Cl, [1]-ratio	[1]- for both Fe & Cl [1]-ratio
(b)(iii)	$2Fe + 3Cl_2 \rightarrow 2FeCl_3$ *Marker's comments:* *To write balanced chemical equation, chlorine is Cl_2, not Cl as chlorine as a diatomic molecule.*	[1]
A4(a)	Volume of hydrogen gas = 45 cm^3 No of moles of hydrogen gas = 45/ 24 000 = 0.001875 mol Mole ratio Mg: H_2 = 1: 1 No of moles of Mg = 0.001875 mol Mass of Mg = 0.001875 x 24 = 0.045 g [1]-mol of gas, [1]- mol & mass of Mg	[1]-mol of gas [1]- mol & mass of Mg
(b) (c)	 [1]- Ea [1]- ΔH [1]-exo + rxts & pdts Note that the arrows are single direction, not double headed! For ΔH, the enthalpy sign "-" is required	[1]- Ea [1]- ΔH [1]-exo + rxts & pdts [1]- (ci)

Enthalpy change will be halved as the no of moles of product produced is halved. Enthalpy change is based on the balanced chemical equation (actual no of moles of product formed). Ea remains unchanged. Ea is only affected by presence of catalyst.

(d)	 *Note: volume of hydrogen gas should be at 22.5 cm^3* *The gradient is gentler and the time reaction ends must be longer than the original of 3.5 mins.*	[1]
(e)	As the temperature increases, the <u>kinetic</u> energy of the particles increases. ("kinetic" energy must be written to gain 1m) **There are more particles with energy greater than or equal to the Ea. (many students missed out this point)** <u>Frequency of effective collisions</u> increases and rate of reaction increases.	[1] [1] [1]
A5 (a)	A weak acid ionises <u>partially</u> in <u>water</u> to produce few <u>H^+ ions</u> in solution. <u>*Marker's comments*</u>*:* *Several students missed out the important key words like "water" and "H^+ ions", besides ionise partially.*	[1]
(b)	$SO_2 + H_2O \rightarrow H_2SO_3$	[1]
(c)	SO_2 is produced from volcanic eruptions or burning of fossil fuels.	[1]
(d)	SO_2 dissolves in the rain water to produce acid rain. Acid rain corrodes **metal** structures and **limestone** buildings/ destroys aquatic animals and plants. <u>*Marker's comments*</u>*:* *Need to talk about harmful effect to gain the 1m. Acid rain is insufficient.* *"Metal" structures or "limestone" buildings are required to show that acid rain react with these chemicals.*	[1]
(d)(i)	**Thermal** decomposition Note: thermal is required	[1]

(d)(ii)	The oxidation state of sulfur <u>increased from +4 in SO_2 to +6 in $CaSO_4$</u>, hence SO_2 is oxidised. *Note: Both oxidation states must be correct to gain full credit. No partial credit given.*	[2]
(d)(iii)	$E_{absorbed}$ = + [635 + 297 + (498/2)] = + 1181 kJ $E_{released}$ = - 1434 kJ ΔH = + 1181 – 1434 = - 253 kJ/mol <u>*Marker's comments:*</u> *Proper statements and units are expected. However, wrong units were not penalised.*	[1] [1]
A6 (a)	The negative yellow coloured CrO_4^{2-} ions move (get attracted) to the positive electrode. <u>*Marker's comments:*</u> *Several students said that CrO_4^{2-} is "discharged" which is incorrect concept. The ion that is discharged is the ion that undergoes reaction, in this case, since it is the anode, it will be oxidation. If CrO_4^{2-} is oxidized, it will no longer be in solution and the solution will not be yellow.*	[1]
(b)	$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$ <u>*Marker's comments:*</u> ***State symbols are required for all half equations!!!!***	[1]
(c)	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ -Cu^{2+} ions are preferentially discharged instead of H^+ ions as they are less stable in solution OR copper is below hydrogen in the reactivity series. -The Cu^{2+} ions <u>gain electrons and are reduced</u> to form copper metal. <u>*Marker's comments:*</u> ***State symbols are required for all half equations!!!!*** *For explanation, both parts are expected, ie why Cu^{2+} is preferentially discharged and Cu^{2+} ions gain electrons and are reduced. However, if either 1 point is given, students are given the 1 m.*	[1] [1]
(d)	Positive electrode: bubbles seen Negative electrode: reddish brown deposit/solid	[1] [1]
(e)	<u>Blue ppt</u> soluble in excess aq ammonia to form a <u>dark blue solution</u>. [Accept: green ppt soluble in excess aq ammonia to form a dark green solution; Blue ppt soluble in excess aq ammonia to form a dark green solution.] 1m- ppt 1m-colour of soln, must mention ppt soluble in excess <u>*Marker's comments:*</u> *Many students did not say "ppt soluble in excess aq ammonia to form…." This is a test of QA, hence this phrase is important.*	[2]

B7(a)	H_2, O_2 …(any diatomic element)	[1]
(b)	Metals have <u>few valence electrons</u> and they tend to <u>lose electrons</u> rather than attract electrons to achieve the stable noble gas electronic configuration, hence they have the lowest electronegativity. <u>*Marker's Comments*</u>: Most knew that metals tend to lose their (valence) electrons, but few explained why.	[1] [1]
(c)	Group 0 elements have the <u>stable noble gas electronic configuration,</u> hence <u>will not bond with other elements/ gain, lose, share electrons</u> and have no affinity (attraction) for electrons. <u>*Marker's Comments*</u>: Many gave incomplete explanations on why Group 0 elements do not form bonds. Since the question is on covalent bonding, specific mention of covalent bonding/ sharing of electrons must be made.	[1] [1]
(d)	 <u>*Marker's Comments*</u>: Generally well done. Assignment of partial charges proved to be challenging for the last molecule.	[1] [1] [1]

(e)	HF > HC*l* > HBr > HI The <u>electronegativity of the halogen decreases down the group</u>. The H-X (where X is the halogen) molecule becomes <u>less polar</u>. The <u>less likely will the hydrogen halide dissociate</u> to form <u>H^+ ions.</u> <u>*Marker's Comments*</u>: Most were able to place the hydrogen halides in order of acid strength. Many explained the reactivity, instead of electronegativity of the halogens. Few then linked to the polarity of the hydrogen-halide bond.	[1] [1] [1] [1]

	Most were able to explain why the hydrogen halides are acids.	
B8(a)	Lead, nickel, zinc, magnesium *Marker's Comments*: Most scored but a few gave the metal oxides instead. Some wrote lead(II) and nickel(II) which refer to the metal ions.	[1]
(b)	Green solid (or oxide) turns white. A grey (silver) metal/solid is seen. Magnesium which is more reactive than nickel displaces nickel from nickel (II) oxide. *Marker's Comments*: Most gave the colour changes of the oxides. While most were able to explain the metal displacement, some were incomplete. Few included the observation for the formation of nickel.	[1] [1] [1]
(c)	Lead (II) oxide AND zinc oxide *Marker's Comments*: Many did not realise that the question is asking for amphoteric oxides. Those who realized often omitted one.	[1]
(d)	magnesium chloride Magnesium chloride which has a lower melting point than magnesium oxide and requires a lower temperature to melt it first before it can conduct electricity, hence more energy is saved/ less energy is used/ lower costs Dilute magnesium chloride cannot be used as magnesium will not be produced/ hydrogen produced instead/ H^+ ions preferentially discharged/ $MgCl_2$ (s) only contains Mg^{2+} and Cl^- ions *Marker's Comments*: Students need to justify their choice of magnesium chloride over magnesium oxide due to the lower melting point of the former and mention the benefit. Vague answers such as it is "easier" to use magnesium chloride are not accepted. Many did not realise that the magnesium chloride has to be in the molten state for it to be an electrolyte.	 [1] [1]
(e)	Melt the solid and check its melting point. Pure magnesium chloride has a fixed melting point of 714^0C or that of the pure solid. *Marker's Comments*: Students should make use of the data given, which is the melting point of magnesium chloride. A handful described the calculation of percentage purity, which wrongly assumes that percentage yield is not 100% solely due to impurities.	[1]

<table>
<tr><td>B9E (a)</td><td>Substance: Crude oil
Process: Fractional distillation

<u>Marker's Comments</u>:
Poorly done. Many wrote the process to be "catalytic cracking".</td><td>[1]
[1]</td></tr>
<tr><td>(b)</td><td><table><tr><td></td><td>C</td><td>H</td></tr><tr><td>No of moles</td><td>85.7/12
= 7.14</td><td>14.3/1
= 14.3</td></tr><tr><td>Mole ratio</td><td>7.14/7.14 = 1</td><td>14.3/7.14 = 2</td></tr></table>
Empirical formula: CH_2

$n(CH_2) = 84$
$n (12 + 2) = 84$
$n = 6$
Molecular formula: C_6H_{12}

<u>Marker's Comments</u>:
Generally well done. Some students used the molecular mass to find the molecular formula directly.</td><td>[1]

[1]

[1]</td></tr>
<tr><td>(c)</td><td>Dodecane will have a higher mpt.

Dodecane and alkene A both have simpler molecular structure.
The <u>size of dodecane is larger</u> than alkene A,

there is <u>stronger intermolecular forces of attraction</u> between the molecules, hence require <u>more energy</u> to overcome.

<u>Marker's Comments</u>:
Students have to compare the size (not just the mass) of the molecules. Many mistakenly thought that the covalent bonds between C and H are broken during melting and discussed about saturatedness etc.</td><td>[1]

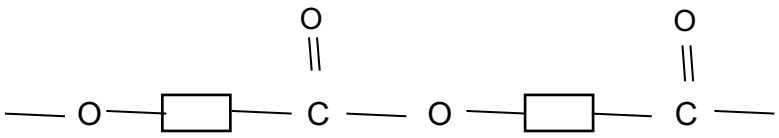
[1]</td></tr>
<tr><td>(d)(i)</td><td>$C_6H_{12} + 9O_2 \rightarrow 6CO_2 + 6H_2O$

<u>Marker's Comments</u>:
Generally okay.</td><td>[1]</td></tr>
<tr><td>(ii)</td><td>No of moles in 12 g of alkene A = 12/84 = 0.14286 mol

Energy released = 0.14286 x (- 4657) = 665 kJ (3sf)

<u>Marker's Comments</u>:
Some students gave the wrong unit of "kJ/mol". Otherwise, the question was well-attempted.</td><td>[1]

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

B9 OR(a)	The particles are closely packed and orderly/neatly. The particles vibrate about their fixed positions. *Marker's Comments*: Generally well done.	[1] [1]
(b) (i)	Condensation polymer *Marker's Comments*: Few scored here. Many did not know the "types" of polymers and many wrote "polymers with ester linkages"	[1]
(ii)	 *Marker's Comments*: Few scored here. Many were confused and drew the polymer or gave the wrong connection of the atoms altogether.	[2]
(c) (i)	No of moles of methanal = 1800/ (12 + 2+ 16) = 60 mol Mole ratio: CH_2O : $CH_2(OH)COOH$ No of moles of $CH_2(OH)COOH$ = 60 mol (allow ECF from 1st step) Mass of $CH_2(OH)COOH$ = 60 x 76 x 45/100 = 2 052 g *Marker's Comments*: Well done. Some forgot to convert mass to g.	[1] [1] [1]
(ii)	Methanal is oxidized as it has gained oxygen. *Marker's Comments*: Well done.	[1] [1]

Paper 1

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

Paper 2

A1 **(a)** **(i)** $^{31}_{15}V^{3-}$, $^{32}_{17}X^{-}$, $^{35}_{17}Z^{-}$ [1]

(ii) $^{31}_{15}V^{3-}$, $^{31}_{15}Y^{-}$ [1]

(iii) $^{31}_{15}V^{3-}$, $^{32}_{15}W^{2-}$, $^{31}_{15}Y^{-}$ or $^{32}_{17}X^{-}$, $^{35}_{17}Z^{-}$ [1]

(b) **(i)** $^{31}_{15}V^{3-}$ [1]

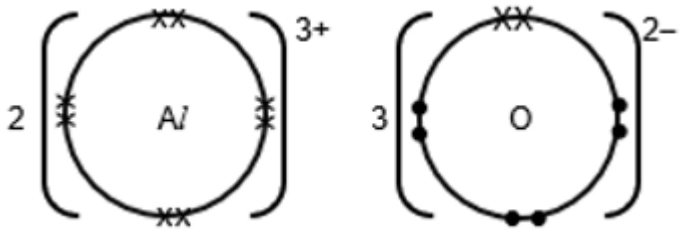
(ii) $^{35}_{17}Z^{-}$ [1]

A2 **(a)**

structure simple molecular structure

bonding covalent bonding [1]

(b) **(i)**



[1] correct no. of electrons transferred

[1] correct charged and ratio

(ii) Oxide ions have a higher charge than fluoride ions, hence the electrostatic forces of attraction is stronger between aluminium and oxide ions than with fluoride ions. [1]

(iii)

Aluminium oxide conducts electricity in the molten/liquid state. (reject aqueous state) [1]

Oppositely-charged aluminium and oxide ions are mobile to carry charges to conduct electricity. [1]

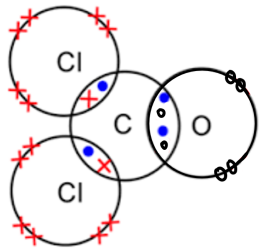
A3 **(a)** Phosgene has a simple molecular structure [1] and a small amount of energy is required to overcome the weak intermolecular forces of attraction between the phosgene molecules. [1]

(b) The arrangement of phosgene particles/molecules will change from being closely packed together but not in an orderly arrangement to being very closely packed together in an orderly arrangement. [1]

The movement of phosgene particles/molecules will change from moving freely within the boundaries of the liquid and sliding over one another to vibrating about fixed positions [1]

(reject if student describe the liquid and solid states as separate points)

(c)



[1] electrons used for sharing
[1] electrons not used for bonding

A4 **(a)** Reaction 1.
Iodide ions are oxidised by hydrogen peroxide as the oxidation state of iodine increases from -1 in iodide ions to 0 in iodine molecules. [1]

(b) $KMnO_4$: +7

$MnSO_4$: +2 [1]

(c)

Purple acidified potassium manganate(VII) solution turns colourless. [1]
Effervescence is observed. [1]

A5 **(a)** **(i)** electrode **A**: $2H^+ (aq) + 2e^- \rightarrow H_2 (g)$ [1]

electrode **B**: $4OH^- (aq) \rightarrow 2H_2O (l) + O_2 (g) + 4e^-$ [1]

(ii) Instead of observing effervescence at electrode A, silvery/grey solid deposits will be formed. [1]

Silver is less reactive than hydrogen, hence silver ions will be selectively discharged over hydrogen ions and be reduced at the cathode to produce silver metal. [1]

(b) **(i)** concentrated copper(II) chloride solution [1]

(ii) $2Cl^- \rightarrow Cl_2 + 2e^-$
$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$

For every 4 moles of electrons,
vol. of O_2 : vol of Cl_2 at electrode D
1 : 2 [1]
30 cm^3 : **60 cm^3** [1]

A6 **(a)** Chlorine is more reactive than iodine and can displace iodide ion from its solution [1]. The solution darkens as iodine solution, which is brown in colour, is formed [1].

(b) The student could add drops of bromine water to potassium iodide solution on a white tile and repeat the addition to potassium chloride solution on a separate tile [1].

Bromine water will cause colourless potassium iodide solution to turn brown while potassium chloride solution remains colourless [1] showing that bromine is more reactive than iodine but is less reactive than chlorine.

A7 **(a)** hydrogen: cracking of crude oil or petroleum/ electrolysis of water
nitrogen: fractional distillation of liquid air [1] for both answers

(b) Ammonia has a higher boiling point than nitrogen and hydrogen [1]. Hence, ammonia will condense to form a liquid first as the mixture of gases are cooled.

(c) 1 mole of nitrogen reacts with 3 moles of hydrogen to form 2 moles of ammonia gas according to the balanced chemical equation [1] (accept chemical equation).

Since 1 mole of a gas occupies 24 dm^3 at room temperature and pressure [1] (or the same number of moles of a gas occupies the same volume at standard temperature and pressure), the volume ratio of nitrogen to hydrogen is kept at 1:3.

(d) Ammonium compounds react with alkali/ calcium hydroxide to form ammonia gas [1]. When ammonia gas escapes into the atmosphere [1], the nitrogen content in the soil is lost and renders the fertilisers ineffective.

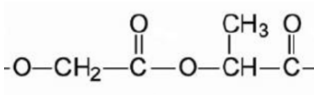
(e) The energy required to maintain the Haber process at 450 ^oC and 200 atm is produced mainly from the <u>combustion of fossil fuels</u> [1] which contributes to the formation of carbon dioxide. [direct energy demands of process]

Hydrogen used as a raw material in the Haber process is produced from natural gas or crude oil through processes which releases carbon dioxide [1]. [hydrogen production]

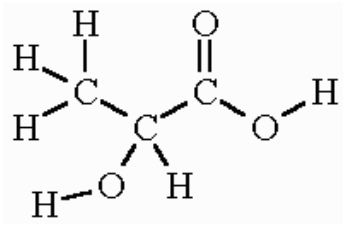
Note: Producing hydrogen from cracking of crude oil and steam reforming of methane both require energy

A8 **(a)** Ester linkage [1]
(do not accept formula –COO-)

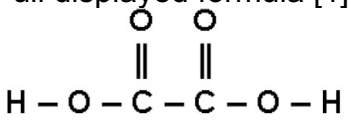
(b)

A repeat unit =  [1]

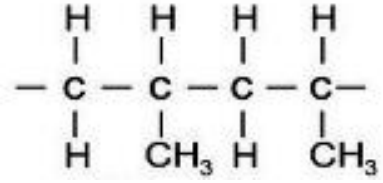
Mr of repeat unit = (12 x 5) + (16 x 4) + (1 x 6)
= 130 [1] [Allow for ECF for incorrect repeat unit] (no unit)

(c)  [2]

Correct formula [1]
Full displayed formula [1]

(d)  [1]

Note: make sure the bonds between O and H are shown

(e) **(i)**  [1]

(ii) In addition polymerisation, the monomers are joined by C-C bonds while in condensation polymerisation, the monomers are joined by ester (-COO-) or amide (-CONH-) linkages. [1]

In addition polymerisation, the monomers must contain C=C bond functional group while in condensation polymerisation, the monomers must contain two functional groups at both ends to allow the polymer chain to grow. [1]

In addition polymerisation, no molecules are lost when the monomers are joined with each other (a single product is formed) while in condensation polymerisation, a small molecule is lost for every linkage formed between the monomers (two different types of products formed). [1]

B9 **(a)** Substitution [1]

(b) Iodine [no mark] is in excess.
Fig. 9.1 shows that propanone is completely used up [1] (concentration decreases to zero) in the reaction, indicating that propanone is the limiting reagent.

(c) **(i)** When the concentration of propanone increases, the initial rate of reaction increases [1]. This is illustrated by **Fig. 9.2**, where a steeper gradient was observed when higher concentrations of propanone were used [1].

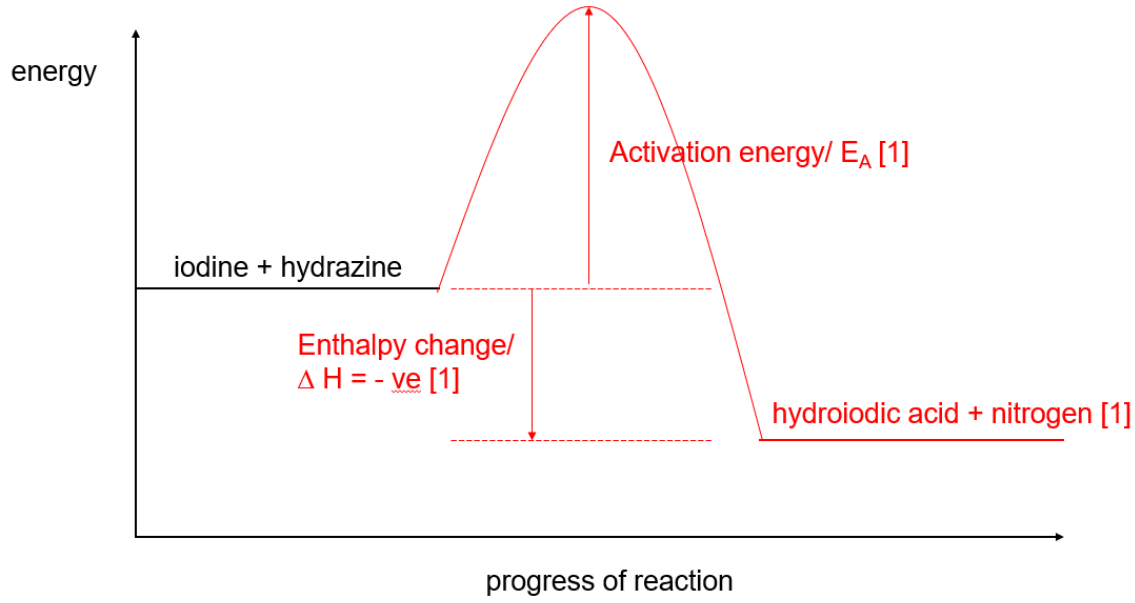
(ii) As the concentration of iodine increases, there is no effect on initial rate of reaction [1]. This is illustrated by **Fig. 9.3**, where the gradient remains constant when higher concentrations of iodine were used [1].

(d) **(i)** $2I_2 + N_2H_4 \rightarrow 4HI + N_2$ [1]

(ii) I_2 is reduced to HI while N_2H_4 is oxidised to N_2 [1].

The oxidation number of iodine decreased from 0 in I_2 to -1 in HI while the oxidation number of nitrogen increased from -2 in N_2H_4 to 0 in N_2 [1].
Since oxidation and reduction occurs simultaneously, the reaction is a redox reaction.

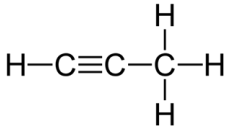
(e)



B10 **(a)** Branching in isomerism decreases the boiling point of a straight chain alkene. [1]
From the data, the boiling point of straight chain butene (-6 °C) is higher than that of branched butene/ alkene 1 (-7 °C) **or** the boiling point of straight chain pentene (30 °C) is higher than that of branched pentene/ alkene 2 (20 °C). [1]

(b) Each successive member of alkynes differ by CH_2 unit **or**
The alkynes follow a general formula of C_nH_{2n-2} [1]
(Do not accept if answer merely state that alkynes have the same functional group C≡C which is not showed by the formulae in Table 10.3)

(c)



[1]

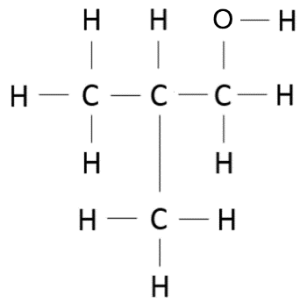
(d) reagent Bromine <u>water</u>/ <u>aqueous</u> bromine [1]

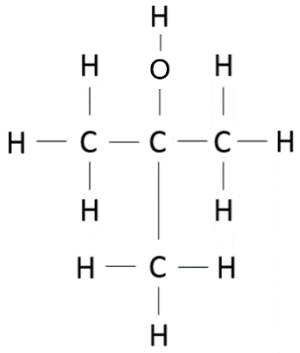
observation for alkyne Reddish-brown aqueous bromine is decolourised/ turned colourless

observation for alkane Aqueous bromine remains reddish-brown

[1] both observations correct

(e) **(i)**





Hydroxyl group at C_1 and C_2 [1]

(ii) The two organic molecules have the same molecular formula of C_4H_9OH but different structural formula (as the position of the hydroxyl group is different) [1]

B11E **(a)** allotropes [1]

(b) High melting point and boiling point. [1] Each phosphorus atom is bonded to three other phosphorus atoms by strong covalent bonds. A large amount of energy is needed to break or weaken all the strong covalent bonds. [1]

Conducts electricity. [1] Two electrons from each phosphorus atom are not used to form covalent bonds. As these delocalised electrons are not used for bonding, they can move about freely and act as charge carriers. [1]

OR Soft and slippery and can be used as a lubricant.
Adjacent layers of phosphorus atoms in phosphorene are not covalently bonded to each other but are attracted to one another by weak forces of attraction. This allows for the layers to slide over one another easily when a small force is applied.

(c) no. of moles of CO_2 = 180 / 24 = 7.5 mol [1]
= no. of moles K_2CO_3 reacted

mass of K_2CO_3 reacted = 7.5 x 138
= 1035 g [1]

% purity of K_2CO_3 = 1035/1750 x 100%
= 59.1% (3 s.f.) [1]

(d) The electronic configuration of phosphorus atoms is 2.8.5 and the electronic configuration of nitrogen atoms is 2.5. [1]
Every phosphorus and nitrogen atom will thus share 3 valence electrons with three hydrogen atoms to obtain a fully filled valence electron shell. [1]

B11 O **(a)** To a sample of malachite, add dilute nitric acid to react with $Cu_2CO_3(OH)_2$. [1]

Filter the mixture to obtain the filtrate. [1]

To 2 cm^3 of the filtrate, add aqueous ammonia with shaking until it is in excess. If copper(II) ions are present, a blue precipitate will be formed and this precipitate is dissolves in excess ammonia, forming a dark blue solution. [1] /
To 2 cm^3 of the filtrate, add sodium hydroxide solution with shaking until it is in excess. If copper(II) ions are present, a blue precipitate will be formed and this precipitate is insoluble in excess sodium hydroxide solution.

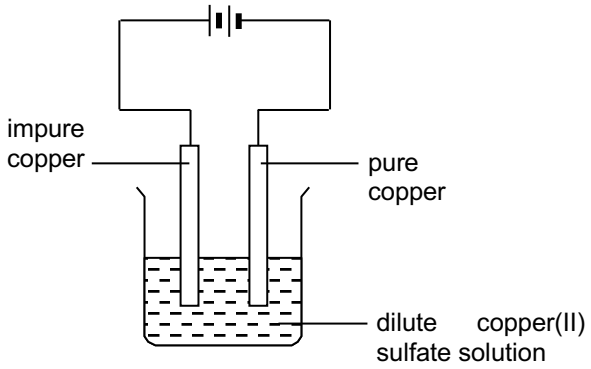
(b) $Cu_2CO_3(OH)_2 \rightarrow 2CuO + CO_2 + H_2O$ [1]
$2CuO + C \rightarrow 2Cu + CO_2$ [1]

(c) Mass of $Cu_2CO_3(OH)_2 = 2 \times 10^6 \times (16.5/100)$
$= 330\,000$ g [1]

% by mass of copper in $Cu_2CO_3(OH)_2 = [(2x64)/222] \times 100$ %
$= 57.7$ % [1]

Mass of Cu that can be extracted $= (57.6577/100) \times 330\,000$
$= 190\,000$ g (3 s.f.) [1]

(d)



[1] Electrodes correctly connected and labelled
[1] Electrolyte correctly chosen

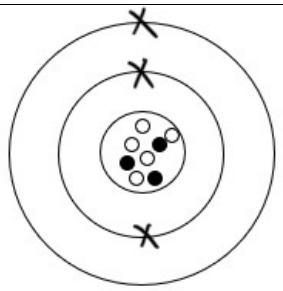
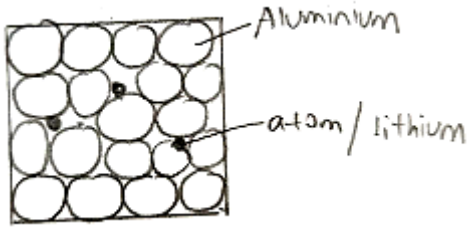
RIVERSIDE SECONDARY SCHOOL

Paper 1

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

Paper 2

<table>
<tr><th>Qn</th><th></th><th>Answers</th><th>Remarks</th><th>Marks</th></tr>
<tr><td>A1</td><td>(a)(i)</td><td>hydroxide</td><td></td><td>1</td></tr>
<tr><td></td><td>(a)(ii)</td><td>iron(II)</td><td></td><td>1</td></tr>
<tr><td></td><td>(a)(iii)</td><td>carbonate</td><td></td><td>1</td></tr>
<tr><td></td><td>(a)(iv)</td><td>ammonium</td><td></td><td>1</td></tr>
<tr><td></td><td>(a)(v)</td><td>copper(II)</td><td></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>
<table>
<tr><th></th><th>true</th><th>false</th></tr>
<tr><td>The separation of mixtures is a chemical process.</td><td></td><td>✓</td></tr>
<tr><td>Simple distillation allows the recovery of ethanol from water.</td><td></td><td>✓</td></tr>
<tr><td>In chromatography, the same substance has different R_f values in different solvents.</td><td>✓</td><td></td></tr>
</table>
</td><td>3 correct – 2m
2 correct – 1m
0-1 correct – 0m</td><td>2</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>A2</td><td>(a)</td><td>
<table>
<tr><th>Particle</th><th>Name of particle</th><th>Relative mass of the particle</th><th>Relative charge on the particle</th></tr>
<tr><td>○</td><td>neutron</td><td>1</td><td>0</td></tr>
<tr><td>●</td><td>proton</td><td>1</td><td>+1</td></tr>
<tr><td>×</td><td>electron</td><td>1/1836 or 1/1840</td><td>-1</td></tr>
</table>
</td><td>4 correct – 2m
2-3 correct – 1m
0-1 correct – 0m</td><td>2</td></tr>
</table>

<table>
<tr><td></td><td>(b)</td><td>  </td><td>reject if other symbols are used to represent electrons</td><td>1</td></tr>
<tr><td></td><td>(c)</td><td> 

[1]

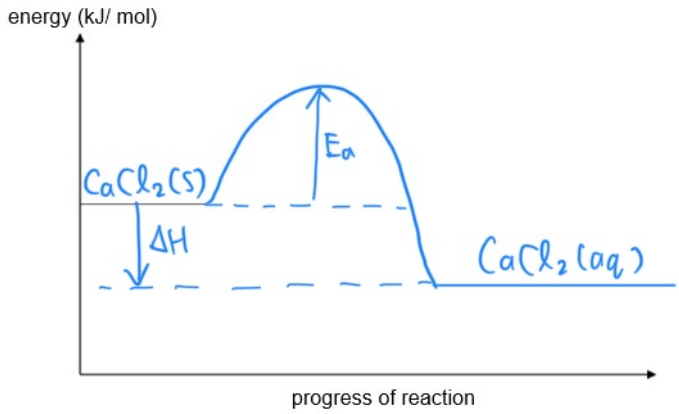
The (lithium) atoms have different size/ smaller size than aluminium atoms and thus disrupt the orderly arrangement of pure aluminium [1]. Hence, difficult for atoms to slide past one another [1].</td><td>(lithium) atom must be minority and smaller in size than aluminium</td><td>3</td></tr>
<tr><td>A3</td><td>(a)</td><td><table>
<tr><th>name of halogen</th><th>density (g/ cm^3)</th><th>melting point (^{o}C)</th></tr>
<tr><td>bromine</td><td>3.21</td><td>-7.3</td></tr>
<tr><td>iodine</td><td>4.94</td><td>114</td></tr>
<tr><td>chlorine</td><td>0.00312</td><td>-102</td></tr>
</table></td><td></td><td>1</td></tr>
<tr><td></td><td>(b)(i)</td><td>chlorine [1]

chlorine is more reactive than bromine [1]</td><td>*accept fluorine</td><td>2</td></tr>
<tr><td></td><td>(b)(ii)</td><td>test: Add dilute nitric acid, followed by aqueous silver nitrate/ acidified silver nitrate [1]

result: yellow precipitate observed [1]</td><td>Must be acidified</td><td>2</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>A4</td><td>(a)</td><td>exothermic reaction</td><td></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>Lithium chloride, as dissolving it with water is exothermic (ΔH = -37 kJ/mol) and thus can heat up the soup. [1]

Dissolving ammonium chloride (ΔH = +25 kJ/mol) with water is endothermic, hence not suitable. [1]

Concentrated sulfuric acid is corrosive/ strong acid, and will corrode tin/ react with tin, hence not suitable. [1]</td><td></td><td>3</td></tr>
</table>

<table>
<tr><td></td><td>(c)</td><td> 
</td><td>1m- correct shape with formula of reactants and products
1m- correct label of Ea with single arrow
1m- correct label of enthalpy change with single arrow</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>A5</td><td>(a)(i)</td><td><table>
<tr><th>element</th><th>oxidation state before the reaction</th><th>oxidation state after the reaction</th></tr>
<tr><td>oxygen</td><td>-1</td><td>-2</td></tr>
<tr><td>iodine</td><td>-1</td><td>0</td></tr>
</table></td><td>1m for each correct row</td><td>2</td></tr>
<tr><td></td><td>(a)(ii)</td><td>Oxygen in H_2O_2 is reduced as the oxidation state decreases from -1 in H_2O_2 to -2 in O_2. Iodine in I^- is oxidised as the oxidation state increases from -1 in I^- to 0 In I_2.</td><td>both oxidation and reduction must be mentioned
ECF from (a)(i)</td><td>1</td></tr>
<tr><td></td><td>(a)(iii)</td><td>colourless to brown</td><td></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>From experiments 1, 2 and 3, when the concentration of KI increases from 0.1 mol/ dm^3, the speed of reaction increases from 0.00017 to 0.00051 mol dm^{-3} /s. [1]

But from experiments 3 and 5, when the concentration of sulfuric acid increases from 0.2 to 0.3 mol/dm^3, the speed of reaction remains unchanged at 0.00017 mol dm^{-3} /s. Hence the student is right. [1]</td><td>1st point- accept any 2 of 3 experiments for comparison

-1m if experiment no./ data not quoted

max 1m if no stand; 0m if stand is wrong</td><td>2</td></tr>
<tr><td></td><td>(c)</td><td>When temperature increases, the iodide ions gain energy/ have more energy, move faster (and collide more frequently).[1]

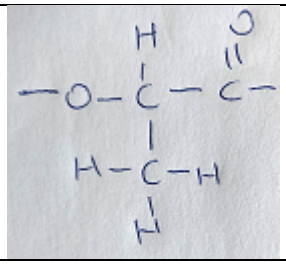
More iodide ions have energy greater than or equal to activation energy.[1]

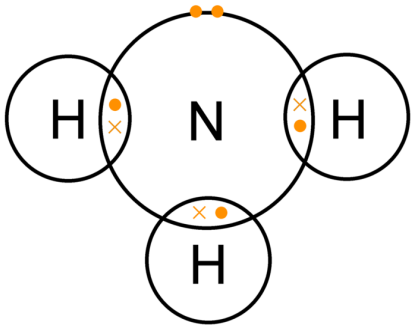
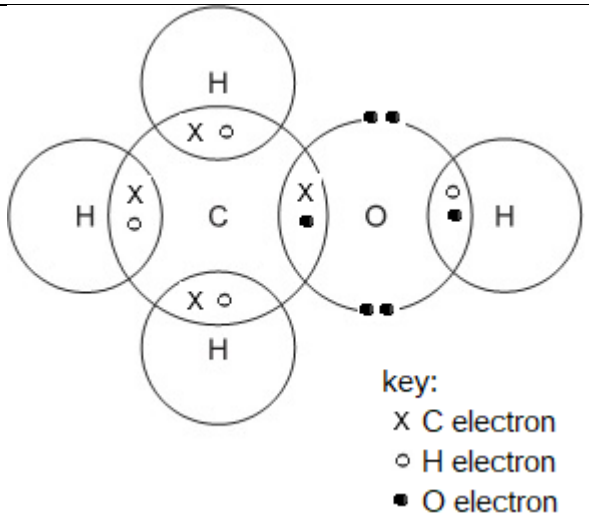
This increases the frequency of effective/ successful collisions between iodide ions and H_2O_2 molecules, leading to an increase in the speed of reaction. [1]</td><td>-1 if iodide ions and H_2O_2 not specified/ wrongly phrased</td><td>3</td></tr>
<tr><td>A6</td><td>(a)</td><td>(Different) boiling point</td><td></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>$C_{11}H_{24}$</td><td></td><td>1</td></tr>
</table>

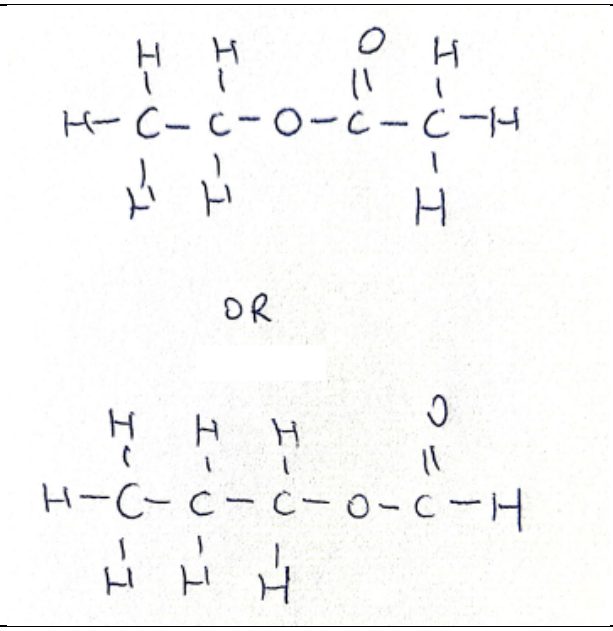
	(c)(i)	Under high temperatures in the jet engine[1], nitrogen and oxygen from the air reacts [1] to form nitrogen monoxide.		2
	(c)(ii)	$N_2 + O_2 \rightarrow 2NO$ no. of moles of N_2 = 55,000 / 14(2) = 1964 mol. (4 sf) N_2 : NO 1 : 2 1964 mol. : 1964 x 2 = 3928 mol. mass of NO = 3928 x (14 + 16) =118,000 g / 118 kg (3 sf)	-1m overall for wrong sf -1m overall for wrong/ missing units	2
	(d)(i)	$O_2 + 2SO_2 \rightarrow 2SO_3$		1
	(d)(ii)	Nitrogen monoxide is not used up as it is regenerated again at the 2nd step/ remains chemically unchanged at the end.	reject if students mention about NO not taking part in the reaction.	1
A7	**(a)**	arrows drawn anti-clockwise		1
	(b)	electrodes B and D	both electrodes must be mentioned	1
	(c)	electrode A: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ electrode B: $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$	1m for each correct equation 1m for correct state symbols	3
	(d)	The electrolyte in cell 1 turns from blue to lighter blue/ colourless. Cu^{2+} ions are discharged over time at the cathode/ electrode A to form Cu. The electrolyte in cell 2 remains blue. For every (mole) of Cu^{2+} ions discharged at the cathode/ electrode C, 1 (mole) of Cu^{2+} is produced at the anode as electrode D dissolves to form Cu^{2+} ions.	1m- correct colour change for both cells 1m for each correct explanation	3

B8	**(a)**	When the distance between the two hydrogen atoms increases, the bond energy decreases [1] to a minimum energy of -432 kJ/mol at 74pm [1] When the distance is greater than 74pm, the H-H bond energy increases to almost 0 kJ/mol. [1]	Answers that only give positive/negative energy will be awarded max. 2m. 1m awarded as long as -432kJ and 74pm mentioned as part of answer.	3

	(b)	As the distance increases from 74 pm, the electrostatic forces of attraction [1] between the valence electrons and the nuclei of both hydrogen atoms get weaker/weakens/decreases [1].		2
	(c)(i)	Agree; O=O has a double bond and a shorter bond length of 121 pm compared to O – O single bond at 148 pm. OR N ≡ N has a triple bond with a bond length of 110 pm which is shorter than N – N at 145 pm	1m- comparing correct bonds 1m- using data to support answer reject comparison between different elements	2
	(c)(ii)	Any number between 115 – 135 pm (actual value = 125 pm)		1
	(d)	Chlorine has 3 electron shell whereas fluorine has 2 electron shells/ chlorine has a larger atomic size/larger atom.[1] The distance between the valence electrons and the nucleus of chlorine is thus further than that of fluorine, and fluorine has a shorter bond length. [1]	must show comparison between Cl and F	2
	(e)	$E_{BB} + E_{BF} = +180$ kJ $942 + 2(494) + E_{BF} = +180$ kJ [1] $E_{BF} = 180 - 1930$ $= -1750$ kJ [1] Alternate answer $E_{BB} = 942 + 2(494) = 1930$ kJ [1] $1930 - E_{BF} = +180$ kJ $E_{BF} = 1750$ kJ [1]		2
B9	**(a)**	Put a piece of blue litmus paper in both lactic acid and styrene. [1] Blue litmus paper turns red in lactic acid and remains blue in styrene. [1] OR add aqueous bromine to both lactic acid and styrene.[1] Aqueous bromine remains reddish-brown in lactic acid but turns colourless in styrene. [1] OR Add any reactive metal/ carbonate into both. Effervescence observed in lactic acid and none in styrene.	accept any simple test for acid reject esterification	2

		OR Add acidified potassium manganate(VII) to both. Lactic acid will turn purple acidified potassium manganate(VII) colourless while acidified potassium manganate(VII) remains purple in styrene.		
	(b)	<u>Similarity</u> Many monomer units of lactic acid and styrene are joined together via covalent bonds to form PLA and polystyrene respectively/ Both involves many monomers joined together to form the polymer[1] <u>Differences</u> Lactic acid monomers undergo condensation polymerisation, with a net loss of H_2O molecules. Styrene monomers undergo addition polymerisation to form polystyrene, with no loss of atoms or molecules. Polymer formed from lactic acid contains ester linkages (reject amide linkage) and polymer formed from styrene containing carbon-carbon single bonds/no ester linkages.	type of polymerization [1] net loss/ no net loss [1]	3
	(c)(i)			1
	(c)(ii)	no. of repeating units = 1,800,000 / [12(3) + 1(4) + 16(2)] = 25,000	ECF from (c)(i)	1
	(d)	Polystyrene is <u>non-biodegradable</u>, hence, not <u>decomposed</u> by bacterial in soil, leading to build up of <u>waste/ take up space in landfill</u>	OWTTE	1
B10 (E)	**(a)**	450 ^oC, 200/250 atm and presence of (finely divided) iron catalyst	3 conditions- 2m 2 conditions- 1m 0-1 condition- 0m	2
	(b)	$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$	1m- balanced equation 1m- state symbols, awarded only if 1st mark is obtained	2
	(c)	% of nitrogen in $NH_4NO_3 = \frac{14(2)}{14(2) + 1(4) + 16(3)} x100\%$ = 35%	-1m overall if missing/ wrong units	1

	(d)		1m- correct no. of shared electrons 1m- correct no. of electrons	2
	(e)	Filter the product mixture and obtain ammonium nitrate as filtrate. [1] Heat the filtrate to saturation and cool to allow crystals to form [1]. Filter to obtain crystals as residue, wash with a little cold distilled water and dry with pieces of filter paper. [1]	No marks as long as the method does not work, i.e. never filter in step 1.	3
B10 **(O)**	**(a)(i)**	substitution reaction [1] ultraviolet light/ UV light/ sunlight [1]		2
	(a)(ii)	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$		1
	(a)(iii)	NaCl		1
	(b)		1m- correct no. of shared electrons 1m- correct no. of electrons Reject if wrong symbol for electrons used.	2
	(c)(i)	methyl propanoate and water		1

	(c)(ii)	 OR 	1m- correct structure 1m- correct bonds 1m given for correct isomers that are not esters	2
	(c)(iii)	Both esters have the same molecular formula but have different structural formula/ structures.		1

SINGAPORE CHINESE GIRLS' SCHOOL

Paper 1

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

Paper 2

Go to: https://drive.google.com/file/d/1T_t1gifLBE7yQWPHS_KkYHGzmIAl3O6q/view?usp=sharing

TEMASEK SECONDARY SCHOOL

Paper 1

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

Paper 2

Go to: https://drive.google.com/file/d/1ZGkhCn55KfwRCa9gQcaqcjp2fhRgd5_T/view?usp=sharing