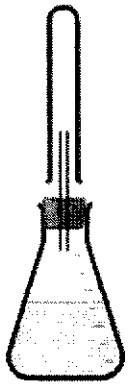
Section A: Multiple Choice Questions [40 marks]
Each question below is provided with 4 options A, B, C and D. Select the most suitable option and shade the corresponding letter A, B, C or D in the Answer Sheet provided.

1 The following apparatus can be used to collect gaseous product.



Which chemical reaction produces a gas that can be collected using the above apparatus?

A $2H_2O_2 \rightarrow 2H_2O + O_2$
B $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$
C $PbO_2 + 4HCl \rightarrow PbCl_2 + Cl_2 + 2H_2O$
D $ZnCO_3 + 2HNO_3 \rightarrow Zn(NO_3)_2 + CO_2 + H_2O$

2 A liquid is thought to be pure ethanol.

What is the best way to test its purity?

A burn it completely in oxygen
B measure its boiling point
C react with ethanoic acid
D test with litmus paper

3 The boiling points of some elements are given in the table.

element	boiling point/ °C
nitrogen	-196
oxygen	-183
xenon	-108

A mixture of nitrogen, xenon and oxygen at -250 °C is heated up to -160 °C.

Which element(s) is/are still in the liquid state at -160 °C.

A xenon
B nitrogen and oxygen
C oxygen and xenon
D all of the above

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4 The rate of diffusion of two gases is measured at different temperatures but at constant pressure.

Which would diffuse most slowly?

A argon at 25 °C
B argon at 60 °C
C nitrogen dioxide at 25 °C
D nitrogen dioxide at 60 °C

5 The relative atomic mass of element **J** is 12.01.

What is the reason that the relative atomic mass of element **J** is not a whole number?

A **J** atoms can have different number of neutrons.
B **J** atoms can have different number of protons.
C Naturally occurring **J** cannot be obtained pure.
D The mass of the electrons have been included.

6 Element **X** has a proton number of 15. Element **Y** has a proton number of 35.

Which of the following properties will a compound formed between **X** and **Y**?

A It has a low boiling point.
B It is able to conduct electricity in liquid state.
C It is inert.
D It is insoluble in organic solvent.

7 Some properties of substances **P**, **Q** and **R** are given in the table below.

substance	percentage composition by mass	electrical conductivity when solid	effect of heat
P	constant	yes	solid burns in air to form an oxide
Q	varies	no	liquid burns to form carbon dioxide and water
R	constant	no	solid decomposes to form two products

Which classification of the substances as an element, a mixture or a compound is correct?

	compound	element	mixture
A	**P**	**Q**	**R**
B	**P**	**R**	**Q**
C	**Q**	**P**	**R**
D	**R**	**P**	**Q**

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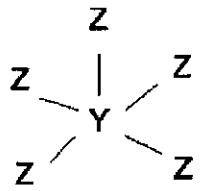
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8 An atom of element **X** is represented by ${}^{9}_{4}X$.

Which statement about an atom of **X** is correct?

A It is in Group IV of the Periodic Table.
B It is in Period 4 of the Periodic Table.
C It forms an ion with a 2+ charge.
D The total number of protons and neutrons is 13.

9 The compound below is made up of elements **Y** and **Z**.



Which groups of the Periodic Table are these elements likely to come from?

	Y	Z
A	III	VII
B	III	I
C	V	I
D	V	VII

10 A substance **F**

(i) has a high melting point;
(ii) is a good conductor of electricity;
(iii) is malleable.

What could **F** be?

A graphite
B iron
C potassium chloride
D silicon dioxide

11 On complete combustion, 4.0 g of hydrocarbon gives 11.0 g of carbon dioxide and 9.0 g of water.

What is the formula of the hydrocarbon?

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

12 What is the formula of uranium(VI) oxide?

A U_6O **C** UO_3
B U_2O_3 **D** UO_6

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13 Chalk is impure calcium carbonate. A piece of chalk has a mass of 23.0 g. When reacted with excess hydrochloric acid, 4.49 dm^3 of carbon dioxide gas was collected at room temperature and pressure.

What is the percentage purity of the piece of chalk?

A 19.5%
B 40.7%
C 55.3%
D 81.3%

14 A solid **X** has the following properties.

(i) It is insoluble in water.
(ii) It gives off a gas when heated.
(iii) It gives off a gas when added to dilute sulfuric acid.

Which one of the following could **X** be?

A calcium hydroxide
B copper(II) carbonate
C potassium carbonate
D sodium sulfate

15 Metal **Y** reacted with dilute hydrochloric acid to form a colourless solution. Aqueous sodium hydroxide was added to this solution and a white precipitate was seen. This precipitate dissolved in excess sodium hydroxide.

What could metal **Y** be?

A calcium
B lead
C iron
D zinc

16 When an excess of lead(II) carbonate reacts with dilute sulfuric acid, the reaction stops after only a small amount of gas has been given off.

Which statement best explains why this happens?

A An insoluble layer of lead(II) sulfate is formed on lead(II) carbonate.
B The concentration of acid decreases rapidly.
C The lead(II) carbonate is unreactive.
D The lead(II) carbonate is impure.

17 Which reactants could be used safely to prepare potassium nitrate?

A aqueous potassium hydroxide and dilute nitric acid
B aqueous potassium sulfate and sodium nitrate
C potassium and aqueous ammonium nitrate
D potassium and dilute nitric acid

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18 Manganese(IV) oxide is a catalyst for the decomposition of hydrogen peroxide.

Which one of the following statements explains why the rate at which oxygen is produced decreases during the reaction?

A Manganese(IV) oxide is used up.
B The reaction absorbs heat energy from the surroundings.
C The surface area of manganese(IV) oxide decreases.
D The solution of hydrogen peroxide becomes more diluted.

19 Solutions of hydrochloric acid and ethanoic acid of the same concentration react completely with 5.0 g of calcium carbonate, in separate containers.

Which statement is correct?

A A smaller volume of CO_2 is produced with ethanoic acid than with hydrochloric acid.
B A greater volume of CO_2 is produced with ethanoic acid than with hydrochloric acid.
C Ethanoic acid reacts slower because it has a lower pH than hydrochloric acid.
D The same volume of CO_2 is produced with ethanoic acid than with hydrochloric acid.

20 Which of the following reactions is endothermic?

A $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$
B $CuCO_3 \rightarrow CuO + CO_2$
C $2H \rightarrow H_2$
D $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

21 Which of the following elements form oxides whose aqueous solution have a pH greater than 7?

1 calcium
2 carbon
3 copper
4 iron

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

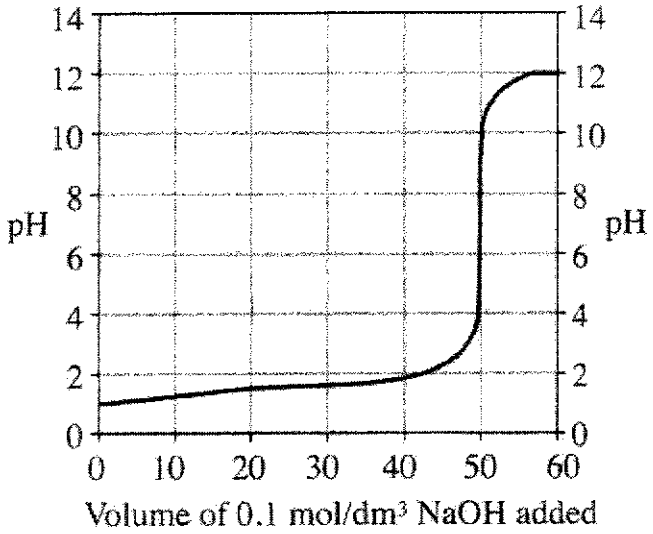
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22 The chart below shows the colours of three indicators at different pH values.

Indicator	Colour change Low pH → high pH	pH which colour change takes place
Methyl orange	Red → yellow	4.0
Bromothymol blue	Yellow → blue	6.5
Phenophthalein	Colourless → pink	9.0

Titration is carried out between sodium hydroxide and dilute hydrochloric acid. The pH change is plotted onto the graph shown below.



Which indicator(s) can be used to identify the end point of this titration.

A methyl orange only
B bromothymol blue only
C bromothymol blue and phenolphthalein only
D all of the above indicators.

23 Aqueous potassium iodide and acidified potassium manganate(VII) solution were added to four solutions separately. The colour changes are seen as shown in the table.

solution	potassium iodide	potassium manganate (VII)
1	colourless to brown	purple to colourless
2	colourless to brown	no change
3	no change	purple to colourless
4	no change	no change

Which solution(s) contain(s) a reducing agent only?

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

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24 Copper reacts with concentrated sulfuric acid, according to the following equation,

$$Cu + H_2SO_4 \rightarrow CuSO_4 + SO_2 + H_2O$$

What is the role of concentrated sulfuric acid in the above reaction?

A It is a catalyst.
B It is a dehydrating agent.
C It is a reducing agent.
D It is an oxidising agent.

25 Rubidium is an element in the same group of the Periodic Table as lithium, sodium and potassium.

Which statement about rubidium is likely to be correct?

A It forms an insoluble hydroxide.
B It is formed by the electrolysis of concentrated rubidium chloride.
C It oxidises readily when exposed to oxygen in the air.
D It reacts slowly with water at room temperature and pressure.

26 The positions of the elements, **V**, **W**, **X**, **Y** and **Z** are shown in the outline part of the Periodic Table.

Period	Group								
	I	II		III	IV	V	VI	VII	0
1									
2	**V**	**W**						**X**	
3	**Y**							**Z**	

Which statement is **not** correct?

A An atom of element **W** has a greater mass than an atom of element **V**.
B Element **Y** has a lower melting point than element **V**.
C Element **Y** will react with element **X** in the ratio of 1:1.
D Element **Z** is more reactive than element **X**.

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27 In each of three experiments, a halogen was added to separate solutions containing ions of the other two halogens.

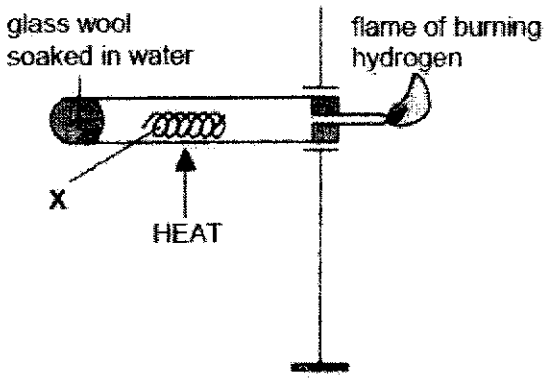
The table shows the results.

experiment	halogen addded	halide solution		
		X^-	Y^-	Z^-
1	X_2	--	Y_2 displaced	Z_2 displaced
2	Y_2	no reaction	--	no reaction
3	Z_2	no reaction	Y_2 displaced	--

What are **X**, **Y** and **Z**?

	X	Y	Z
A	Br	Cl	I
B	Br	I	Cl
C	Cl	Br	I
D	Cl	I	Br

28 Based on the setup as shown in the diagram below, what is substance **X** most likely to be?



A **X** is a metal below hydrogen in the reactivity series.
B **X** is a metal above hydrogen in the reactivity series.
C **X** is an oxide of a metal that is below hydrogen in the reactivity series.
D **X** is an oxide of a metal that is above hydrogen in the reactivity series.

29 Which substance found in car exhaust fumes is not a pollutant?

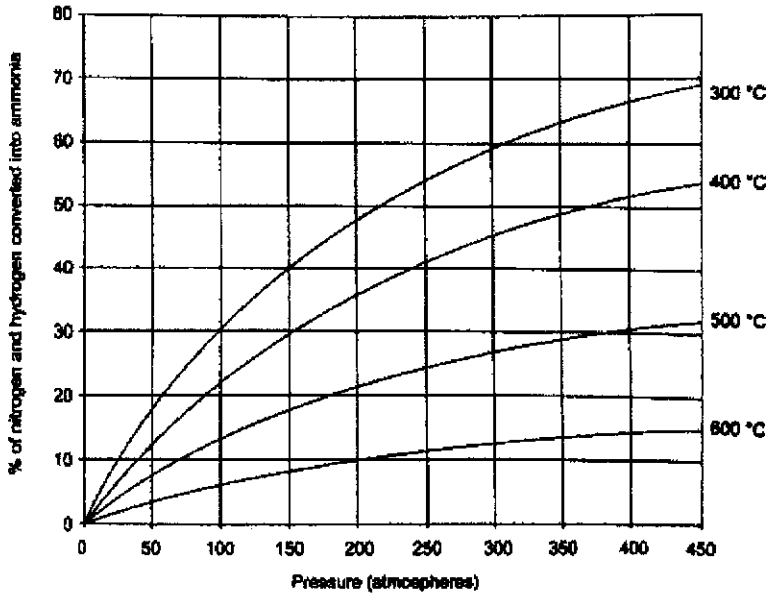
A carbon monoxide
B nitrogen
C nitrogen dioxide
D Unburnt hydrocarbons

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30 The graph below gives the percentage conversion of nitrogen and hydrogen under different conditions.

The equation for the reaction is given as

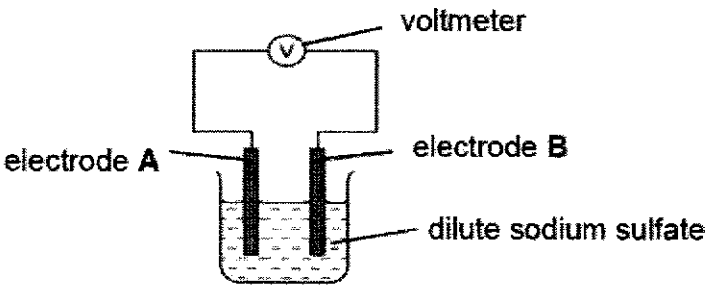
$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad \Delta H = -92 \text{ kJ}$$



Which of the following statements is correct?

A Finely divided nickel is used to catalyse the reaction.
B The backward reaction is an exothermic process.
C The yield of ammonia decreases with decreasing temperature.
D The yield of ammonia increases with increasing pressure.

31 A simple cell was set up as shown.



Which pair of electrodes would give the largest reading on the voltmeter, and which electrode will be the positive terminal?

	electrode **A**	electrode **B**	positive terminal
A	copper	iron	copper
B	iron	silver	silver
C	magnesium	copper	magnesium
D	zinc	magnesium	zinc

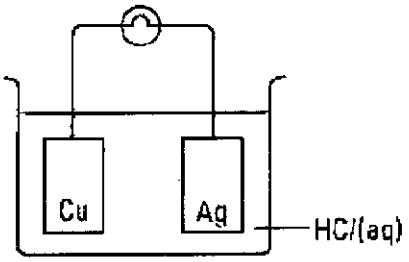
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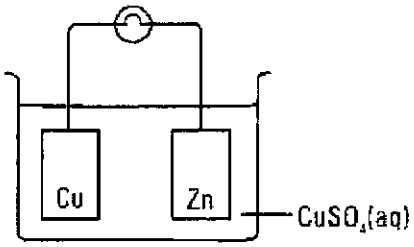
32 Four experimental set-ups are shown below.

Which set-up will the pH of electrolyte increase around the copper electrode?

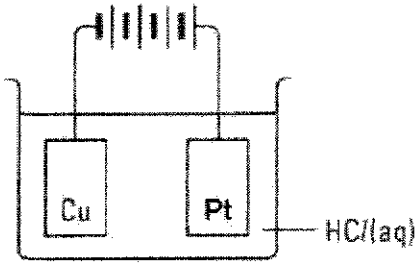
A



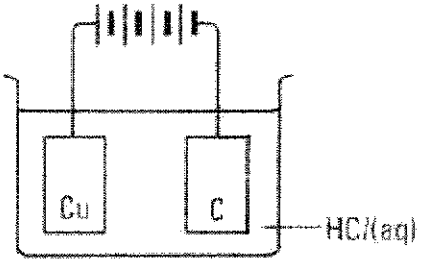
C



B



D



33 Useful fractions are obtained by the fractional distillation of petroleum.

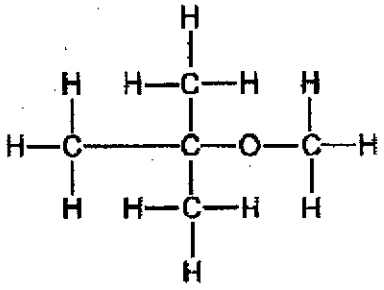
Which of the following fractions and its uses are correct?

	fraction	use
A	bitumen	fuel in cars
B	kerosene	for making roads
C	lubricating oils	for making waxes and polishes
D	petrol	aircraft fuel

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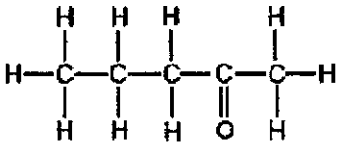
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34 The structural formula of compound **X** is shown.

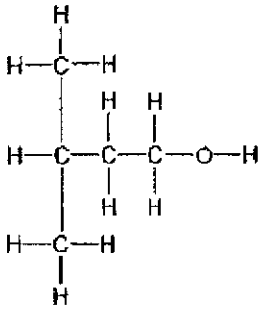


Which of the following compound is an isomer of compound **X**?

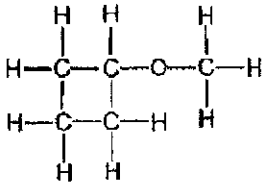
A



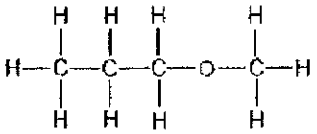
B



C



D



35 Which one of the following properties of propanoic acid is not a typical property of an acid?

A Its aqueous solution has a pH less than 7.
B It burns in air to give water and carbon dioxide.
C It reacts with magnesium to give a salt and hydrogen gas.
D It reacts with magnesium oxide to give a salt and water.

36 A hydrocarbon (relative molecular mass, 44) will react with chlorine only in the presence of light.

Which one of the following is the hydrocarbon?

A CH_4
B C_2H_4O
C C_3H_6
D C_3H_8

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37 Catalytic addition of steam to hydrocarbon **X** forms compound **Y**. Compound **Y** can be oxidised to compound **Z**.

What could **X**, **Y** and **Z** be?

	X	Y	Z
A	C_2H_4	C_2H_5OH	CH_3COOH
B	C_2H_6	C_2H_5OH	CH_3COOH
C	C_3H_6	C_3H_8	C_2H_5COOH
D	C_3H_8	C_2H_5COOH	C_3H_7OH

38 The table shows the energy given out by four compounds when they are burnt completely.

compound	relative molecular mass	ΔH/ kJ per mol
C_4H_9OH	74	-2650
C_2H_5OH	46	-1400
CH_4	16	-900
C_3H_8	44	-2200

Which compound produces the least amount of energy when 1 g of it is burnt completely?

A CH_4
B C_2H_5OH
C C_3H_8
D C_4H_9OH

39 An ester of molecular formula, $C_4H_8O_2$ was produced by reacting an alcohol with a carboxylic acid. Several alcohols and acids are shown below.

	alcohol	acid
1	ethanol	ethanoic acid
2	methanol	butanoic acid
3	propanol	methanoic acid

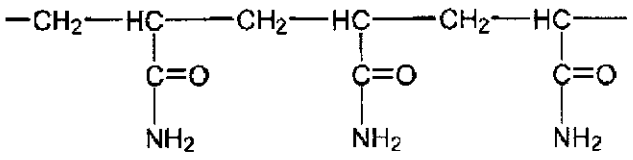
Which of the following could be the alcohol and the acid?

A 3 only
B 1 and 2 only
C 1 and 3 only
D all of the above

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40 Polyacrylamide is used to manufacture soft contact lenses. Part of the polymer is shown below.



Which statements about polyacrylamide are correct?

1 It is formed by addition polymerisation.
2 It contains ester linkages.
3 The molecular formula of its monomer is C_3H_5NO.

A 1 and 2 only
B 2 and 3 only
C 1 and 3 only
D all of the above

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Section A

Answer **all** questions in the spaces provided.
The total mark for this section is 50.

A1 **(a)** Use the list of substances to answer the questions.

carbon

carbon dioxide

chlorine

iron

neon

nitrogen dioxide

phosphorus

(i) Which substance forms a compound with hydrogen with the formula, XH_3.

..... [1]

(ii) Which substance is produced at high temperatures in car engines?

..... [1]

(iii) Which substance is a major constituent of stainless steel?

..... [1]

(iv) Which **two** substances are reducing agents?

..... [1]

(v) Which substance is unreactive?

..... [1]

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(b) Which of the statements about the processes in the blast furnace are true and which are false?

Put a tick (√) in one box in each row.

	true	**false**
Carbon in coke reacts with oxygen to form carbon dioxide.		
Carbon monoxide reduces iron(III) oxide in haematite to form molten iron.		
Limestone reacts with sand to form molten slag.		
Molten slag sinks to the bottom of the furnace.		

[2]

[Total: 7]

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A2 The Haber process is an important process to produce ammonia, which is used as a feedstock to produce fertilisers for agricultural use.

The process is costly as the raw materials, nitrogen and hydrogen need to be obtained by processes that require energy.

The table below shows the bond energies of some bonds.

bond	bond energy/ kJ/mol
H – H	436
O – H	460
N – N	160
N ≡ N	944

(a) Hydrogen reacts with nitrogen to produce ammonia in the equation below.

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g) \qquad \Delta H = -91.8\ kJ$$

Calculate the bond energy of the N – H bond in kJ/mol.

[2]

(b) Use ideas about breaking and forming bonds to explain why the enthalpy change for the process is negative.

.....

.....

.....

..... [2]

(c) Finely divided iron is used as a catalyst in the Haber process.

What other essential industry conditions is necessary for making ammonia from nitrogen and hydrogen?

.....

..... [1]

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(d) Draw an energy profile diagram to show the effect of the catalyst on the Haber process.

Your diagram should show and label

- reactants and products,
- the activation energy for the uncatalysed and catalysed reactions,
- the enthalpy change of reaction.



[3]

(e) Use ideas about collisions between particles to explain, how a catalyst increases the rate of reaction.

.....

.....

.....

..... [2]

(f) Catalysts are expensive to buy but it reduces costs in the long run.

Give a reason to explain why catalysts reduce costs in the long run.

.....

..... [1]

[Total: 11]

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A3 Germanium, an element with proton number of 32, was discovered by Clemens Alexander Wrinkler at Freiberg, Germany, in 1886. It is in the same Group as carbon and silicon.

(a) Germanium tetrachloride is a colourless liquid with melting point -49.5 °C.

Draw a 'dot and cross' diagram to show the bonding in germanium tetrachloride. Show outer shell electrons only.

[2]

(b) Germanium dioxide, GeO_2, has a structure similar to silicon dioxide. Explain, in terms of structure and bonding, the difference in the melting point of germanium dioxide and germanium tetrachloride.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 5]

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A4 The table below shows some information about two copper ores, tenorite and cuprite. Both contain copper oxide.

ore	formula of copper oxide in ore	oxidation number of copper	percentage of copper by mass
tenorite		+2	80.0%
cuprite	Cu_2O		

(a) **(i)** What is the formula of the copper compound in tenorite?

..... [1]

(ii) What is the oxidation state of copper in cuprite?

..... [1]

(iii) Calculate the percentage of copper by mass in cuprite.

[1]

(b) **(i)** Charcoal (carbon) is added to tenorite to form copper and a gas. The gas that was produced forms a white precipitate in limewater.

Write an equation, with state symbols, for the extraction of copper from tenorite.

..... [2]

(ii) The equation in **(b)(i)** shows that extraction of copper from tenorite is a redox reaction.

Use ideas about oxidation state to explain why this statement is true.

.....

.....

.....

..... [2]

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(c) Another ore of copper, chalcocite, contains copper(II) sulfide.

Complete the 'dot and cross' diagram below for the sulfide ion showing outer electrons only.

[2]

[Total: 9]

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A5 Small pieces of a silvery metal, **E**, were added to concentrated nitric acid. A brown gas, **F**, and a colourless solution containing salt **G** were formed.

Analysis of a sample of gas **F** showed it contained 1.07 g of nitrogen and 2.43 g of oxygen.

The small sample of the colourless solution of **G** was diluted with water and then divided into two portions.

To one portion, aqueous sodium hydroxide was added drop by drop until it was in excess. A white precipitate **D** was formed that did not dissolve in excess sodium hydroxide.

To the other portion, aqueous ammonia was added drop by drop until it was in excess. There was no observable change.

(a) Name the following substances.

(i) precipitate **D** .....

(ii) metal **E** .....

(iii) solution **G** .....

[3]

(b) Write the ionic equation for the formation of white precipitate **D** when sodium hydroxide was added to solution **G**.

..... [1]

(c) Given the information above, determine the empirical formula of gas **F**.

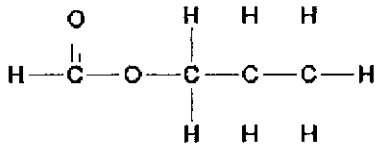
[2]

[Total: 6]

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A6 This is the structure of an ester made in a reaction between a carboxylic acid and an alcohol.



(a) **(i)** State the conditions for this reaction.

..... [1]

(ii) What is the name of the ester?

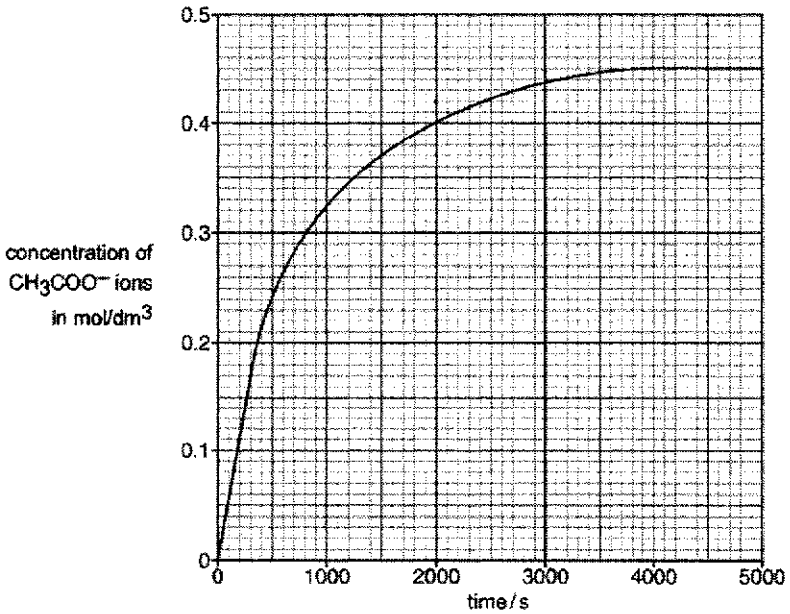
..... [1]

(iii) Write an equation for this reaction.

..... [1]

(b) Another ester, ethyl ethanoate, reacts with sodium hydroxide to form sodium ethanoate and ethanol.

The graph shows how the concentration of ethanoate ions, CH_3COO^-, changes as the reaction proceeds.



Explain briefly the change in the rate of reaction with time.

.....

.....

.....

..... [2]

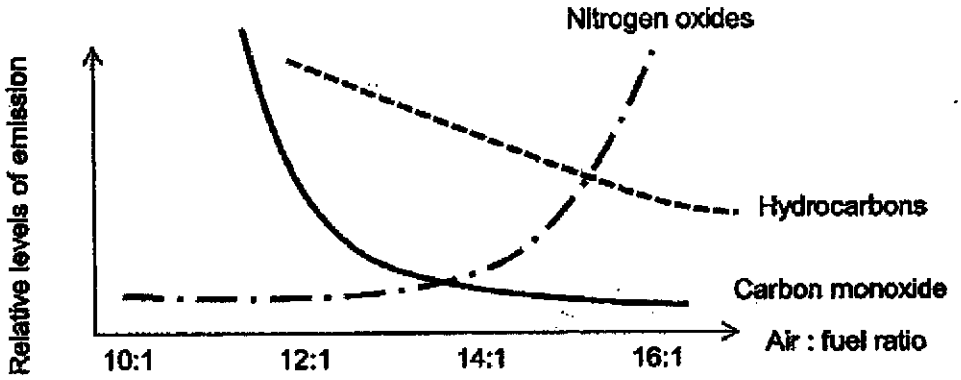
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A7 Most vehicles are operated using petrol engine.

For vehicles which are run by petrol engine, air : fuel ratio in the engine plays an important role to determine the relative levels of emission of different air pollutants as shown in the diagram given below.



(a) How is carbon monoxide formed in a car engine?

.....

..... [1]

(b) Use the information from the diagram to show that lesser pollutants are released when petrol is burnt in excess oxygen.

.....

..... [1]

(c) Suggest why the level of nitrogen oxides increases when the air : fuel ratio is greater than 14 : 1.

.....

.....

.....

.....

..... [2]

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(d) **(i)** Catalytic converters installed in cars reduce the amounts of carbon monoxide and nitrogen oxides from cars.

Write an equation to show how a catalytic converter reduces the amounts of carbon monoxide and nitrogen oxides from cars.

equation: ..... [1]

(ii) Catalytic converters do not solve all environmental problems.

Explain why this is so.

.....

..... [2]

[Total: 7]

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Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 Read the information about the elements in Group II of the Periodic Table.

element	number of shells of electrons in atom	atomic radius/ pm	ionic radius/ pm	effect of adding metal to water
magnesium	3	150	66	reacts very slowly
calcium	4	180	99	reacts quickly with water
strontium	5	200	134	reacts vigorously with water

(1 000 000 000 000 pm = 1m)

Thermal stability of Group II elements and its polarising power

Polarisation is the distortion of the electron cloud of an anion by a positively charged particle. The ability of a cation to polarise an anion is called its polarising power. An approximate measure of the polarising power of a cation is its charge density.

Charge density is proportional to $\frac{charge\ of\ cation}{ionic\ radius}$.

Group II hydroxides decompose on heating to form metal oxides and steam. The temperature at which the metal hydroxides decompose are shown in the table below.

metal hydroxide	decomposition temperature/ °C
$Mg(OH)_2$	332
$Ca(OH)_2$	520 – 580
$Sr(OH)_2$	500 – 850

(a) (i) What is the relationship between atomic radius and the reactivity of the metals in Group II?

..... [1]

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(ii) Explain the relationship in **(a)(i)**.

.....

.....

.....

.....

..... [2]

(b) Suggest why the radius of magnesium atom changes when it forms a magnesium ion.

.....

.....

..... [1]

(c) **(i)** Determine which ion, Mg^{2+}, Ca^{2+} or Sr^{2+}, has the highest polarising power.

..... [1]

(ii) A student proposes that the temperature at which Group II metal hydroxides decompose depends on the polarising power.

Does the information given support the idea of the student?

Explain your reasoning.

.....

.....

.....

.....

.....

..... [3]

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(d) Strontium chloride is useful in reducing tooth sensitivity by forming a barrier over the teeth. A way to produce strontium chloride in the lab is to react strontium hydroxide with an acid.

(i) Name the acid that is added to react with strontium hydroxide.

..... [1]

(ii) Write a balanced chemical equation for the reaction.

..... [1]

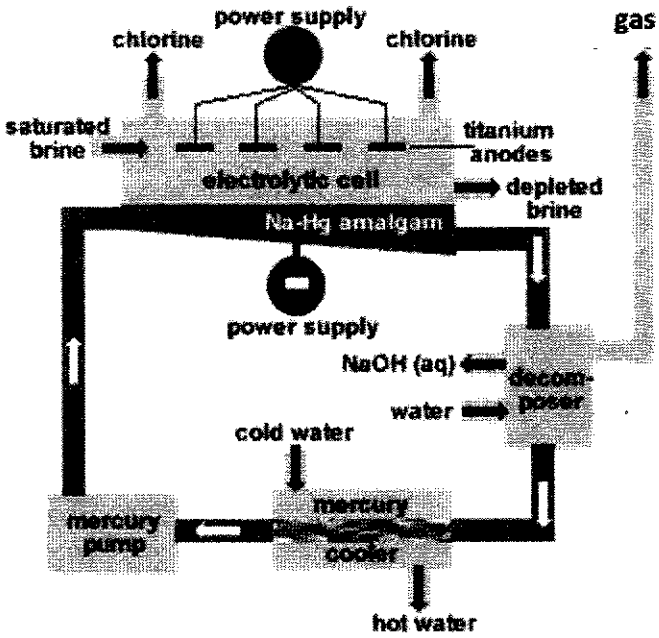
[Total: 10]

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B8 Castner-Kellner cell can be used to perform electrolysis of brine. Brine is saturated sodium chloride solution. The cell is used to produce sodium hydroxide and chlorine gas.



(image taken from: https://www.worldofchemicals.com/media/methods-of-preparation-of-caustic-soda/6748.html)

In the Castner-Kellner cell, the cathode is the mercury that flows along the bottom of the cell. Sodium solid and chlorine gas are produced as the product of the electrolysis.

Sodium dissolves in the liquid mercury to form Na-Hg amalgam (alloy of sodium and mercury). The amalgam flows into the decomposer. In the decomposer, the sodium is extracted from the amalgam and reacts with water to form sodium hydroxide and a gas.

(a) (i) Write the ionic half equation that happens at the anode.

..... [1]

(ii) Describe a simple test that would confirm the identity of the element formed at the anode. Include the result of the test in your answer.

.....

..... [1]

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(b) Calculate the mass of solid sodium formed when 3600 dm^3 of chlorine gas measured at room temperature and pressure is formed at the anode.

[3]

(c) Write a balanced chemical equation for the reaction in the decomposer.

..... [1]

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(d) Besides using electrolysis for the production of sodium hydroxide and chlorine gas, electrolysis can also be used to deposit a thin layer of metal over another metal with the help of electric current. This process is known as electroplating.

Nickel is the most common electroplated material. Nickel electroplating can be used in the automotive industry. It can be found on bumpers, rims and exhaust pipes.

(i) Draw a well labelled diagram, including all the chemical reagents used, to show how nickel can be plated on the rim of the car tyre.

[2]

(ii) Suggest a benefit of nickel electroplating on the rim of the tyre.

Explain your answer.

.....

.....

.....

..... [2]

[Total: 10]

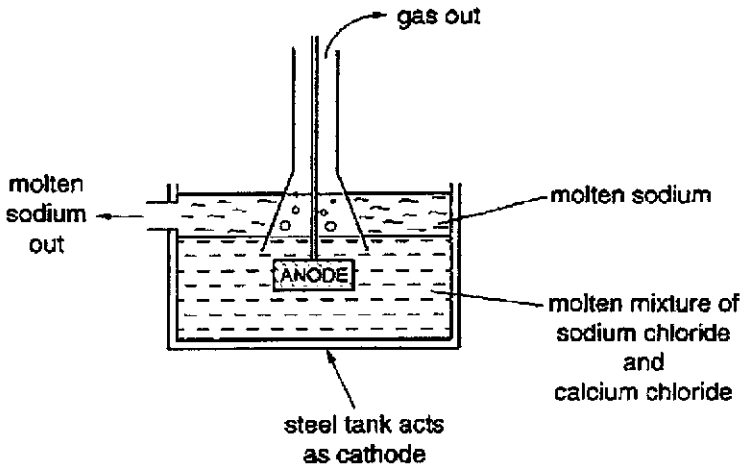
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Either

B9 Sodium metal is extracted from molten sodium chloride by electrolysis.

The diagram shows how the process works.



(a) Write a single equation, with state symbols, to show the products of the electrolysis of sodium chloride.

..... [2]

(b) Describe a simple test and its result that would identify the gas given off at the anode.

.....

.....

..... [2]

(c) Calcium chloride is added to the sodium chloride to lower the melting point of the mixture.

(i) Explain why lowering the melting point makes the process cheaper to run.

.....

.....

.....

..... [2]

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(ii) The molten sodium contains metallic impurities.

Name the main metal impurity you would expect to find and explain how it forms.

.....

.....

..... [2]

(d) Sodium chloride can also be electrolysed in aqueous solution.

Describe the differences in the products of the electrolysis of concentrated aqueous sodium chloride compared to molten sodium chloride.

.....

.....

.....

..... [2]

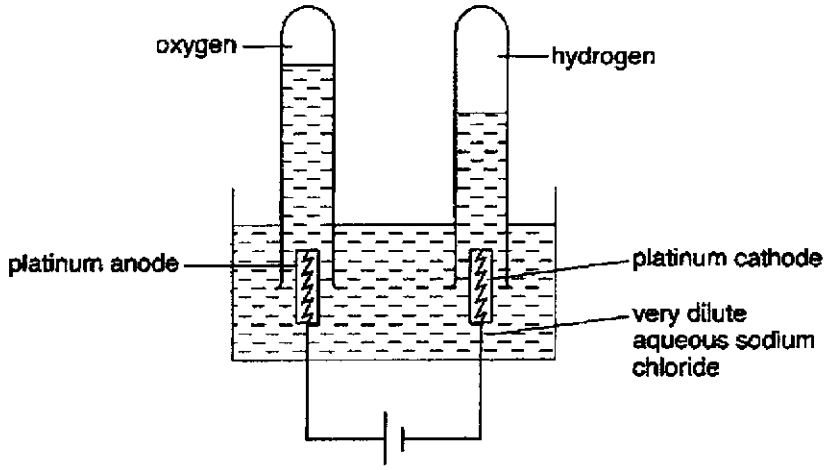
[Total: 10]

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Or

B9 An experiment is carried out to electrolyse very dilute aqueous sodium chloride.



(a) (i) Write equations for the reactions that happen at each electrode during the electrolysis.

.....

..... [2]

(ii) Is the reaction at anode an oxidation or a reduction reaction?

Explain your reasoning.

.....

..... [1]

(b) (i) During the reaction, 4.8 cm^3 of oxygen is collected.

Calculate the mass of 4.8 cm^3 of oxygen at room temperature and pressure.

[2]

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(ii) Hydrogen is collected during the reaction.

What volume of hydrogen forms when 4.8 cm^3 oxygen forms?

[2]

(c) After the electrolysis has been running for some time, the solution becomes more concentrated.

What are the products of the electrolysis when the solution becomes more concentrated?

Explain your reasoning.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

-End of Paper-

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Ngee Ann Secondary School

2021 Sec 4E Pure Chemistry (6092):Preliminary Examination

Paper 2

Suggested Answers

For questions on mole concept, the following errors will penalised (over the whole paper)
- Lack of unit / wrong unit
- Lack of statement / wrong statement
- Final answer not expressed to 3 sf

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2021 Secondary 4 Pure Chemistry (6092)
Prelim Paper 1
Suggested Answers

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

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Ngee Ann Secondary School

2021 Sec 4E Pure Chemistry (6092): Preliminary Examination

Paper 2: Suggested Answers

<table>
<tr><td>A1</td><td>(a)(i)</td><td>Phosphorus</td><td>1</td></tr>
<tr><td></td><td>(ii)</td><td>Nitrogen dioxide</td><td>1</td></tr>
<tr><td></td><td>(iii)</td><td>Iron</td><td>1</td></tr>
<tr><td></td><td>(iv)</td><td>Iron and carbon</td><td>1</td></tr>
<tr><td></td><td>(v)</td><td>Neon</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>Carbon in coke reacts with oxygen to form carbon dioxide</td><td>√</td><td></td></tr>
<tr><td>Carbon monoxide reduces iron(III) oxide in haematite to form molten iron.</td><td>√</td><td></td></tr>
<tr><td>Limestone reacts with sand to form molten slag.</td><td></td><td>√</td></tr>
<tr><td>Molten slag sinks to the bottom of the furnace.</td><td></td><td>√</td></tr>
</table>
1 m for every 2 correct answers.
</td><td>2</td></tr>
<tr><td>A2</td><td>(a)</td><td>Let the bond energy of N – H be x kJ/mol.

Energy taken in to break the bonds
= 944 + 3(436)
= 2252 kJ

Energy given out to form the bonds
= 2(3)x kJ

-6x + (+2252) = -91.8
x = 391 kJ/mol (3 sf)</td><td>1

1</td></tr>
<tr><td></td><td>(b)</td><td>The enthalpy change is negative as the energy given out/released to form the bonds in ammonia is greater than the

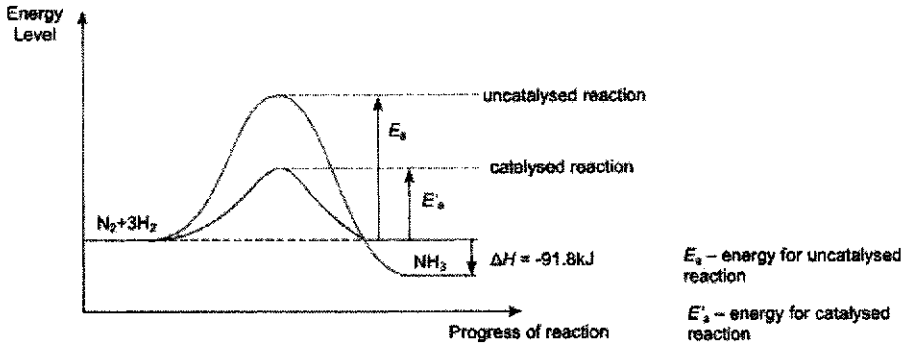
energy taken in/absorbed to break the bonds in nitrogen and hydrogen.

or</td><td>1

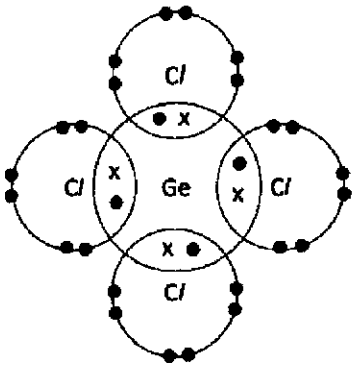
1</td></tr>
</table>

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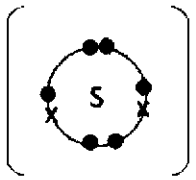
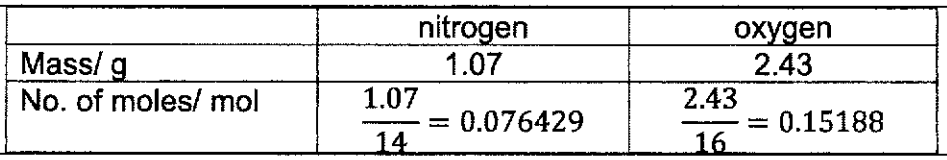
		The enthalpy change is negative as the **energy taken in to break the bonds in nitrogen and hydrogen** is **less than** the **energy given out to form the bonds in ammonia.**	
	(c)	250 atm and 450 °C	1
	(d)	 1m – correct position and formulae of reactants and products and shape of graph 1m – correct direction and labelling of activation energies 1m – correct direction and labelling of enthalpy change	3
	(e)	Catalyst provides an **alternative pathway with a lower activation energy for the reaction** to occur. (There will be more molecules that possess energy greater than the activation energy.) This **increases the frequency of effective collisions**. Hence the rate of reaction increases.	1 1
	(f)	Increase the speed of reaction and produce more products Higher yield in a shorter period of time Not consumed/ not used up/ remains chemically unchanged and can be reused after the reaction Any one of the above	1

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A3	**(a)**	 1m – correct 'dot and cross' diagram 1m – correct key (only if diagram is correct) -1m if no key	2
	(b)	Germanium dioxide has a **giant molecular structure**. A **lot of heat** energy is required to **overcome** the **strong covalent bonds between the germanium and oxygen atom**. On the other hand, germanium tetrachloride has a **simple molecular structure** and exists as **discrete molecules**. A **little amount of heat** energy is required to **overcome** the **weak intermolecular forces of attraction between the molecule.** Hence germanium dioxide will have a higher melting point than germanium tetrachloride. 1m – correct identification of structure 1m – correct identification of the type of interactions to overcome 1m – how much energy is needed to overcome Or 1m – correct identifying correct structure and bonding for germanium dioxide when melting. 1m – correct identifying correct structure and bonding for germanium tetrachloride when melting. 1m – how much energy is needed to overcome "break intermolecular forces of attraction" is not accepted.	3
A4	**(a)(i)**	CuO	1
	(ii)	+2	1

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	(iii)	Percentage of copper in cuprite $= \frac{2(64)}{2(64)+16} \times 100\%$ = 88.9% (3 sf)	1
	(b)(i)	$2CuO\ (s) + C\ (s) \rightarrow CO_2\ (g) + 2Cu\ (s)$ 1m – correct balanced equation 1m – correct state symbols (equation must be balanced)	2
	(b)(ii)	**Copper in copper(II) oxide/ copper(II) oxide** is **reduced** as the oxidation state of **copper decreased** from **+2 in copper(II) oxide** to **0 in copper**. **Carbon** is **oxidised** as the oxidation state of **carbon increased** from **0 in carbon** to **+4 in carbon dioxide**. Hence this is a redox reaction. Allow ecf from (b)(i)	1 1
	(c)	 2- Key: x – electron of Cu ● – electron of S 1m – correct drawing of sulfide ion 1m – correct key (only if drawing is correct)	2
A5	(a)(i)	Calcium hydroxide	1
	(ii)	Calcium	1
	(iii)	Calcium nitrate	1
	(b)	$Ca^{2+}\ (aq) + 2OH^-\ (aq) \rightarrow Ca(OH)_2\ (s)$ Allow ECF	1
	(c)		1

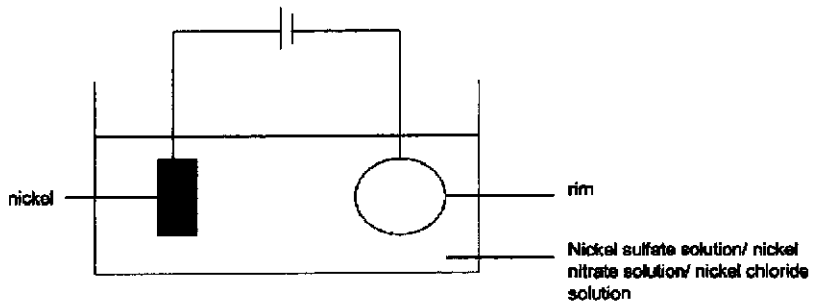
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		÷by smallest no. | $\frac{0.076429}{0.076429} = 1$ | $\frac{0.15188}{0.076429} = 1.9872$ Simplest ratio | 1 | 2 Empirical formula | NO_2 1m – correct number of moles for each elements 1m – correct empirical formula	1
A6	**(a)(i)**	Concentrated sulfuric acid, strong heating/ heat/ heat under reflux	1
	(ii)	Propylmethanoate	1
	(iii)	$CH_2O_2 + C_3H_7OH \rightleftharpoons C_4H_8O_2 + H_2O$ Or $HCOOH + CH_3CH_2CH_2OH \rightleftharpoons HCOOCH_2CH_2CH_3 + H_2O$	1
	(b)	The **rate of reaction was the fastest** at the **beginning** as the **concentration of the reactants (hydroxide ions and ethyl ethanoate)** were the **highest**. As the reaction proceeds, the rate of reaction decreases with time as the **concentration of the reactants (hydroxide ions and ethyl ethanoate) decreases, until reaction stops/ reactants are used up.**	1 1
A7	**(a)**	Carbon monoxide is produced from the **incomplete combustion of the car fuel**. Or Carbon monoxide is produced when the **car fuel burns in insufficient oxygen in the air.**	1
	(b)	Amount of oxygen is in excess as **the air : fuel ratio increases**. This results in the **relative level emission of carbon monoxide and hydrocarbons to decrease**.	1
	(c)	High in air : fuel ratio results in **complete combustion** which will then result in large amount of energy to be released. **More energy is given out/ higher temperature** results in **more nitrogen to react with the oxygen to form nitrogen oxides**.	1 1

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		1m is awarded if students wrote this "More oxygen is present to react with nitrogen."	
	(d)(i)	Catalytic converter $2CO + 2NO \rightarrow 2CO_2 + N_2$	1 1
	(d)(ii)	**Carbon dioxide** which is a **greenhouse gas** will still be evolved. **Excess carbon dioxide** will **enhance greenhouse effect** and leads to **global warming**.	1 1
B7	**(a)(i)**	As the atomic radius increases, the reactivity of the metals increases.	1
	(a)(ii)	As the **atomic radius increases**, the **valence electrons** are **further away** from the attraction of the **nucleus**. As a result, it is **easier for the valence electrons to be lost**, hence the **reactivity** of metals in Group II **increases down the group**.	1 1
	(b)	Magnesium **atom loses two valence electrons** to form magnesium **ion** as a result the **number of electron shells containing electrons decreases** as a result, there is a **decrease of the radius** when magnesium ion.	1
	(c)(i)	Mg^{2+}	1
	(c)(ii)	The **ionic radius** of the Group II metal **ions increases down the group**, since **charge density is inversely proportional to the ionic radius**, the **charge density decreases down the group**, with magnesium having the largest charge density and strontium the lowest. The **polarising power of the group II ions decreases down the group** as well. The **decomposition temperature suggests that when the polarising power decreases**, the **decomposition temperature of hydroxide increases**. Therefore, there is a relationship and the information supports the idea.	1 1 1
	(d)(i)	Hydrochloric acid	1
	(ii)	$Sr(OH)_2 + HCl \rightarrow SrCl_2 + H_2O$	1

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B8	**(a)(i)**	$2Cl^-$ (aq) → Cl_2 (g) + $2e^-$	1
	(ii)	Place a **moist blue litmus paper** above the opening. If the **moist blue litmus paper turns red then bleaches**, then chlorine gas is present.	1
	(b)	$2Cl^-$ (aq) → Cl_2 (g) + $2e^-$ Na^+ (aq) + e^- → Na (s) $2Na^+$ (aq) + $2e^-$ → 2Na (s) No of moles of chlorine gas = $\frac{3600}{24}$ = 150 mol -- 1 Mole ratio of Cl_2 : e^- = 1:2 No of moles of e^- = 2(150) = 300 mol --1 Mole ratio of Na : e^- = 1:1 No of moles of Na = 300 mol Mass of Na = 300(23) = 6900 g – 1	3
	(c)	$2Na + 2H_2O \rightarrow 2NaOH + H_2$	1
	(d)(i)	 1m – correct labelling of anode and cathode 1m – correct electrolyte	2
	(ii)	Nickel electroplating can provide **corrosion protection/ resistant to corrosion.** Nickel can act as a **protective layer** around the rim, **preventing it from coming into direct contact with the oxygen in the air and moisture** that can lead to corrosion.	1 1
Either			
B9	**(a)**	$2NaCl$ (l) → 2Na (l) + Cl_2 (g) 1m correct chemical equation	2

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		1m correct state symbol (only award for correct chemical equation)	
	(b)	Hold a piece of moist blue litmus paper into the gas. If the moist blue litmus paper red, then bleaches it, then chlorine gas is present.	1 1
	(c)(i)	**Lesser heat / energy** is required to heat the mixture to **keep it in molten state.** This helps to **save on electricity** and hence cheaper. The cost of a high temperature process is linked to the energy, electricity or fuel use. This needs to be stated clearly. Not accepted: it costs a lot to heat it up	1 1
	(ii)	The impurity is **calcium.** **Calcium ions** present **accepts electrons/reduced at the cathode** to form metallic calcium.	1 1
	(c)	For concentrated aqueous sodium chloride, **hydrogen gas is formed at the cathode**, for molten sodium chloride, **molten sodium is formed at the cathode.** For concentrated aqueous sodium chloride, **the resultant electrolyte will be aqueous sodium hydroxide** but for **molten sodium chloride, there is no change in the electrolyte.** Chlorine gas is formed at the anode for both systems.	1 1
Or			
B9	**(a)(i)**	Anode: $4OH^-$ (aq) → $2H_2O$ (l) + O_2 (g) + $4e^-$ Cathode: $2H^+$ (aq) + $2e^-$ → H_2 (g)	1 1
	(ii)	Oxidation as hydroxide ions loses electrons.	1
	(b)(i)	No. of mole of O_2 $= \frac{0.0048}{24}$ = 0.0002 mol Mass of oxygen gas = 0.0002 x (16x2) = 0.00640 g (3 sf)	 1 1

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	(ii)	Overall equation: $2\ H_2O \rightarrow 2H_2 + O_2$ Mole ratio of $H_2 : O_2 = 2 : 1$ Volume of gas is proportional to number of moles of gas. Volume of H_2 formed = $2 \times 4.8 = 9.60\ cm^3$ (3 sf)	1 1
	(d)	The products are **hydrogen gas, chlorine gas and aqueous sodium hydroxide.** Hydrogen gas is produced at the **cathode** as **hydrogen ion** is **preferentially discharged** over **sodium ions**. Chlorine gas is produced at the **anode** as **chloride** has a **high concentration than hydroxide ions**. **Loss of hydrogen ions and chloride ions** from the electrolyte (sodium chloride solution) will result in the **formation of sodium hydroxide.** 1m each is given for stating and explaining the products when the solution becomes more concentrated.	1 1 1 1

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