Name _____ Reg. No _____ Class _____

4EX

PURE CHEMISTRY 6092/02
Paper 2
[80 Marks]

PRELIMINARY EXAMINATION
August 2022
1 hour 45 minutes

Additional Materials:
Approved calculator

INSTRUCTIONS TO CANDIDATES:

Do not open this booklet until you are told to do so.
Write your name, index number and class in the spaces at the top of this page and on any separate answer paper used.
Write in dark blue or black pen on both sides of the paper.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the space provided.

Paper 2: Section B
Answer **three** questions in the space provided. The last question is in the form of an either/or and only one of the alternatives should be attempted.

FOR EXAMINER'S USE	
Section	**Marks**
Paper 1 MCQ	/ 40
Paper 2: A	/ 50
Paper 2: B	
B 8	/ 12
B 9	/ 8
B10 Either / Or	/ 10

INFORMATION FOR CANDIDATES:
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 **23**.

This question paper consists of 23 printed pages

Setter: Chen Yanhui Timothy Vetter: Mdm Jarina Banu

Section A (50 marks)

Answer all the questions in this section in the spaces provided.

A1 Choose from the following compounds to answer the questions below.

ammonium sulfate
calcium oxide
copper(II) chloride
carbon monoxide
ethene
nitrogen monoxide
sodium iodide
sulfur dioxide

Each compound can be used once, more than once or not at all.

Which compound

(a) may be formed when alkanes are cracked,

..... [1]

(b) forms a yellow precipitate with aqueous silver nitrate,

..... [1]

(c) is used as a fertilizer,

..... [1]

(d) is used by farmers to reduce soil acidity,

..... [1]

(e) forms an acidic solution when it reacts with water?

..... [1]

[Total: 5]

A2 Tungsten, also known as wolfram, was first isolated as a metal in 1781 from tungsten(VI) oxide, WO_3.

In the natural state, tungsten can be found as four different particles, namely tungsten-182, tungsten-183, tungsten-184 and tungsten-186.

(a) Which of the following statements is/are true for tungsten?

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

	True	False
It has a low melting point.		
It forms coloured compounds.		
The compounds can act as good catalyst for reactions		
It contains electrons in a sea of delocalised ions.		

[2]

(b) **(i)** What is the term used to describe the four particles of tungsten?

..... [1]

(ii) Compare and contrast the number of sub-atomic particles in nucleus of the four particles of tungsten.

.....

.....

.....

..... [2]

[Total: 5]

A3 Pure germanium is a semiconductor with an appearance similar to elemental silicon. Like silicon, germanium naturally reacts in oxygen in air to form germanium(IV) oxide.

Having a similar structure to silicon dioxide, it is used in the making of infra-red transparent glasses in the military because it is **mechanically strong** and transparent.

(a) Using the chemical equation given below, explain, in terms of oxidation state, why this is a redox reaction.

$$Ge + O_2 \rightarrow GeO_2$$

Explanation:

.....

.....

..... [2]

(b) **(i)** Predict the structure found in germanium(IV) oxide.

..... [1]

(ii) Hence, explain in terms of bonding, why germanium(IV) oxide is **mechanically strong**.

.....

.....

.....

.....

..... [2]

(c) (i) Germanium also reacts with chlorine to form germanium tetrachloride which has a simple molecular structure.

Draw the 'dot and cross' diagram of germanium tetrachloride. (Show only valence electrons.)

[2]

(ii) Predict and explain if germanium tetrachloride is able to conduct electricity.

.....

.....

.....

..... [2]

[Total: 9]

A4 Alkynes are a homologous series of organic compounds. Alkynes contain the C≡C group. They react in a similar way to alkenes.

Table 4.1 shows some information about the first five alkynes.

Table 4.1

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

(a) Suggest the name of the alkyne with the molecular formula C_4H_6.

..... [1]

(b) Draw the full structural formula of propyne.

[1]

(c) Estimate the boiling point of hexyne and write its molecular formula.

Boiling point: .....

Molecular formula: ..... [2]

(d) (i) A bottle of propyne and propane respectively had their labels removed.

Suggest a chemical test to determine their identity and describe the observations of the chemical test.

.....

.....

.....

..... [2]

(ii) Alkynes undergo addition reactions similar to alkenes.

Suggest the conditions for making propane from propyne and write a balanced chemical equation for the reaction.

Conditions: .....

Chemical equation: ..... [2]

[Total: 8]

A5 Aqueous copper(II) sulfate was electrolysed in two cells using different electrodes as shown in Fig. 5.1.

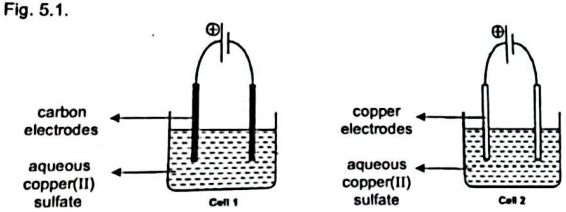


Fig. 5.1

(a) Write ionic equations, with state symbols, for the reactions which take place at the anode in each cell.

anode reaction in Cell 1: .....

anode reaction in Cell 2: ..... [2]

(b) Describe one change that you would see happen in both cells.

.....

..... [1]

(c) Describe one change that you would see happen in Cell 1 but not in Cell 2.

.....

..... [1]

(d) The electrolysis process was allowed to run for about 10 minutes. Universal indicator was then added to the electrolyte in both cells.

Describe what happens to the colour of Universal indicator in both Cell 1 and 2. Explain your answer.

.....

.....

.....

.....

.....

..... [2]

[Total: 6]

A6 Methane, methanol and hydrogen have been investigated as possible alternative fuels for motor vehicles that currently use petrol.
Table 6.1 below compares the energy released on combustion of these fuels.

The enthalpy change of combustion of a substance, ΔHc, is defined as the energy released when one mole of the substance is completely burnt in oxygen.

Table 6.1

fuel	density / g/dm^3	ΔH_c / kJ/mol	energy per gram / kJ/g
petrol	710 – 770	–	47.3
methane	0.645	–891	55.7
methanol	792	–726	?
hydrogen	0.0884	–286	143

(a) Methane and methanol undergo complete combustion to give the same products.

(i) Write an equation for the complete combustion of methanol.

..... [2]

(ii) Which fuel, methane or methanol, is likely to give sootier exhaust products when it is combusted in the same volume of air in the motor vehicle engine?

Explain your answer.

You may include calculations in your answer.

.....

.....

..... [2]

(iii) Calculate the energy per gram for methanol in kJ/g.

[1]

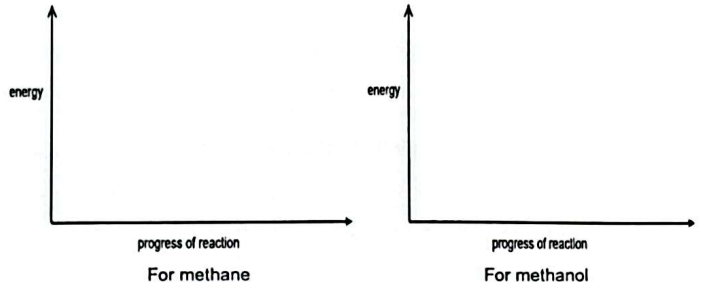
(iv) Methanol is harder to ignite as compared to methane as more energy is required to start the combustion.

Hence, draw the energy profile to compare the combustion for both methane and methanol.

Your diagram should show and label

- the activation energy and enthalpy change of reaction.

You are not required to show the reactants and products of the reaction.



For methane For methanol

[3]

(b) With reference to Table 6.1, list out one advantage and one disadvantage of using methane and hydrogen as an alternative source of fuel compared to petrol.

.....

.....

.....

..... [2]

[Total: 10]

A7 Nitrogen monoxide and hydrogen reacts at 400°C according to the following equation.

$$2NO\,(g) + 2H_2\,(g) \rightarrow N_2\,(g) + 2H_2O\,(g)$$

Different initial concentrations of nitrogen monoxide and hydrogen were used to investigate the rate of reaction. In each experiment, the initial rate of reaction was measured.

Table 7.1 shows the results obtained in each experiment.

Table 7.1

experiment	initial concentration of NO / mol dm^{-3}	initial concentration of H_2 / mol dm^{-3}	initial rate of reaction / mol dm^{-3} s^{-1}
1	0.0060	0.0010	1.8×10^{-4}
2	0.0060	0.0020	3.6×10^{-4}
3	0.0010	0.0060	0.3×10^{-4}
4	0.0020	0.0060	1.2×10^{-4}
5	0.0040	0.0030	?

(a) A student makes the following comment.

'Changing the concentration of nitrogen monoxide changes the rate of reaction to the same extent as changing the concentration of hydrogen gas.'

Does the information in the table support the statement made by the student?
Explain your reasoning.

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Turn over

(b) Experiment 5 was conducted using 0.0040 mol dm^{-3} of NO and 0.0030 mol dm^{-3} of H_2.

Predict the initial rate of formation of N_2.

..... [1]

(c) Explain, in terms of collisions between reacting particles, how operating at a lower temperature of 250°C affects the rate of reaction in the reactor.

.....

.....

.....

.....

.....

..... [3]

[Total: 7]

---- End of Section A ----

Section B (30 marks)

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

B8 What is hard water?

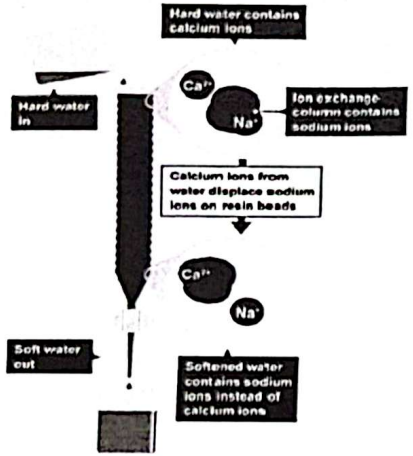
Hard water contains calcium ions which get into water when rainwater containing dissolved carbon dioxide reacts with limestone to form calcium hydrogen carbonate solution.

Hard water and soap

Soap typically contains $C_{17}H_{35}COO^-$ as the stearate anion. Soap only works when stearate anions are in the solution. The calcium ions present in hard water removes the stearate ions in a precipitation reaction forming calcium stearate (white scum). A lather will not form until all the calcium ions in hard water have reacted with the stearate ions to form scum. In hard water areas, this involves wasting lots of soap as well as the unpleasantness of washing in water with a thick layer of scum on it.

Besides the formation of scum, hard water also forms limescale (calcium carbonate) when it is heated. Limescale can eventually block pipes and leads to a waste of energy. Limescale coating the heating element in an electric kettle slows transfer of heat to the water. Limescale can be removed by using descalers or vinegar.

Removing ions that cause hard water



Hardwater can be softened by addition of washing soda which contains sodium carbonate. The water is then filtered to obtain soft water.

Domestic water softeners consist of small beads of ion exchange resin packed into a container. The hard water flows through this and comes out at the other end as soft water.

The ion exchange resin exchanges other positive ions for sodium ions. The resin is a complex lattice with sodium ions attached to it. Calcium ions in hard water stick to the lattice and the sodium ions are washed off.

Some ion exchange resins replace both positive and negative ions with hydrogen and hydroxide ions. The water emerging from such resins is known as deionised water.

(a) Knowing that hydrogen carbonate has a formula of HCO_3^-,

Write the chemical formula for calcium hydrogen carbonate and, hence, a balanced chemical equation for the formation of calcium hydrogen carbonate.

Formula: .....

Chemical equation: ..... [2]

(b) In terms of bonding and structure, explain why limescale is a poor conductor of electricity at room temperature and pressure.

.....

.....

..... [2]

(c) Explain why vinegar can be used in place of descalers to remove limescale in a kettle.

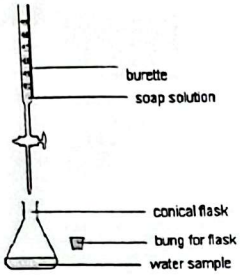
.....

.....

..... [2]

(d) Hardness of water can be tested by adding soap solution, drop by drop, to a known volume of water sample as shown. The water is shaken vigorously after each addition to check for the formation of lather. Lather will form when the calcium ion in the hard water is removed. The volume of soap solution needed to form the lather is recorded.

The table below shows results for this experiment on two samples of water.



water	volume of soap / cm^3
sample **A**	1.7
sample **B**	4.3

In terms of ions present, explain which sample contains higher hardness of water.

.....

.....

..... [2]

(e) Explain how the addition of sodium carbonate can remove the ions that cause hard water.

.....

.....

..... [2]

(f) When all the sodium ions in the resin have been used up, the domestic water softener will stop working and needs to be regenerated.

Describe a test that can be carried out to the water emerging from the resins to determine that the water softener has stopped working.

.....

.....

..... [2]

[Total: 12]

B9 **(a)** Fig. 9.1 shows a cell that can be used to make electrical energy using different metals.

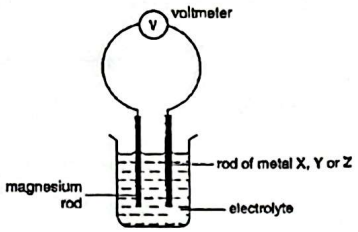


Fig. 9.1

(i) Suggest why distilled water is not used as an electrolyte.

.....

..... [1]

(ii) Table 9.2 shows the results when rods of three metals, **X**, **Y** and copper, are used in separate experiments.

Table 9.2

rod 1	rod 2	voltmeter reading/V
magnesium	copper	2.72
magnesium	X	-0.78
magnesium	Y	1.10

Place the metals in order of reactivity.

most reactive .....

.....

.....

least reactive .....

[2]

[Turn over

(b) A student carried out experiments using three reagents, **A**, **B**, **C** and **D**.

In each test he added a different reagent to separate fresh samples of green aqueous iron(II) chloride and green aqueous iron(II) sulfate.

Table 9.3 shows what reagents he used.

Table 9.3

	reagent
A	magnesium powder
B	acidified aqueous silver nitrate
C	acidified aqueous barium nitrate
D	aqueous ammonia

(i) Which two reagents give the same observation for both aqueous iron(II) chloride and aqueous iron(II) sulfate?

..... [1]

(ii) Describe what the student would observe when he adds each of the three reagents to separate fresh samples of aqueous iron(II) chloride and aqueous iron(II) sulfate.

.....

.....

.....

.....

.....

.....

.....

.....

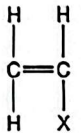
.....

..... [4]

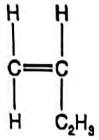
[Total: 8]

Either

B10 Styrene-butadiene rubber is a synthetic rubber. It is made by polymerising a mixture of the monomers, butadiene and styrene.



styrene



butadiene

(a) What type of polymerisation will take place when the monomers polymerise?

Explain your reasoning.

.....

.....

..... [2]

(b) One possible structure for the polymer is shown below.

(i) Draw the structural formula for two repeating units in this polymer structure.

[2]

(ii) When the mixture of styrene and butadiene polymerises, the polymer is unlikely to contain only this regular, repeating pattern.

Suggest a reason.

.....

.....

..... [1]

(iii) Disposal of styrene-butadiene rubber can requires burning and the process releases carbon dioxide into the atmosphere. This means that disposal of nylon has a carbon footprint. The carbon footprint is the mass of carbon dioxide that is given off per kilogram of styrene-butadiene rubber.

Knowing that 1 mole of the repeating unit of styrene-butadiene rubber produces 12 moles carbon dioxide, calculate the number of repeating units in styrene-butadiene rubber if its carbon footprint is 24 g. (Assuming X has a relative mass of 77).

[3]

(c) Butadiene can be made by cracking butane in a cracking tower.

Butane cracks to form butadiene and one other product.

(i) Write an equation to show this reaction.

..... [1]

(ii) Give a use of the other product in this reaction.

..... [1]

[Total: 10]

Or

B10 Rubbing alcohol are liquids used primarily as a topical antiseptic. They also have multiple industrial and household applications.

A typical rubbing alcohol contains 70% of propanol.

(a) Propanol is manufactured by the addition reaction of gaseous propene and another substance.

(i) Name the substance and thus write the chemical equation for the manufacturing of propanol.

Substance: .....

Chemical equation: ..... [2]

(ii) Propanol can exist as isomers as well.

Draw the full structural formula of two isomers that can be formed during the manufacturing of propanol.

[2]

(iii) The rubbing alcohol in a bottle has a mass of 40 g.

Calculate the volume of propene that is required to make enough propanol in rubbing alcohol to fill the bottle.

[3]

[Turn over

(b) Propanol can be used to manufacture esters, which are used widely for flavourings.

In one chemical plant, propanol is used to react with ethanoic acid to produce an ester.

(i) Name the ester formed.

..... [1]

(ii) Write the full structural equation for this reaction.

[2]

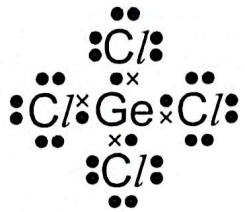
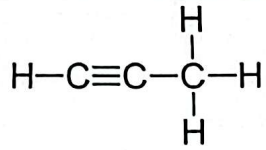
[Total: 10]

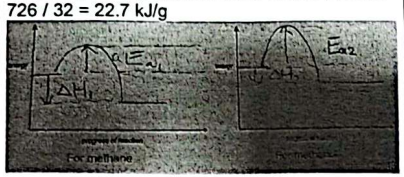
***Prelim* 4Ex Chem 2022 – Answer scheme**

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
C	C	A	B	D	D	A	C	C	B
Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
B	C	D	D	A	B	A	D	B	D
Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
A	B	C	D	B	D	C	A	D	A
Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40
C	B	C	A	B	A	C	B	A	A

P2 Section A:

	Suggested answers	marks	Remarks
A1 (a) (b) (c) (d) (e)	 ethene sodium iodide ammonium sulfate calcium oxide sulfur dioxide / ethanoic acid	 [1] [1] [1] [1] [1]	
A2 (a)	 F T T F	 [1] [1]	
(b) (i) (ii)	 Isotopes All these particles have 74 protons in their nucleus while tungsten-182, tungsten-183, tungsten-184 and tungsten-186 have 108 neutrons, 109 neutrons, 110 neutrons and 112 neutrons respectively.	 [1] [1] [1]	
A3 (a)	 Germanium is oxidised as the oxidation state of germanium increases from 0 to +4 While oxygen is reduced as the oxidation state decreases from 0 to -2.	[1] [1]	
(b)	Giant molecular structure.	[1]	
(c)	Since gemanium(IV) oxide consist of a giant molecular structure, And because a there is **strong covalent** bonds between germanium and oxygen atoms, **a lot of energy** is required to overcome these bonds, resulting in it being strong.	 [1] [1]	

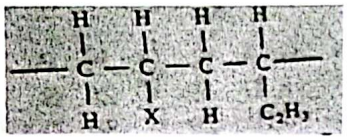
	Suggested answers	marks	Remarks
(c) (i)		[1m for correct sharing of electrons] [1m for correct electronic configuration]	
(ii)	No Since it has a simple molecular structure, and therefore, it does not have any **mobile electrons or ions** to carry charge to conduct electricity	[1] [1]	
A4 (a)	 butyne	 [1]	
(b)		[1]	
(c)	70 – 90℃ C_6H_{10}	[1] [1]	
(d) (i) (ii)	 Add aqueous bromine to samples of the two solutions. Aqueous bromine decolourises in propyne while aqueous bromine remains reddish brown in propane. 200℃ and nickel $C_3H_4 + 2H_2 \rightarrow C_3H_8$	 [1] [1] [1] [1]	
A5 (a)	 $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$ $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	1 1	
(b)	The cathode will increase in size / electroplated with a reddish brown solid.	1	
(c)	The solution in cell 1 will be less blue over time while cell 2 will remain blue longer / The anode in cell 2 will become smaller over time while the anode 1 in cell 1 will remain the same size.	1	
(d)	In cell 1, the universal indicator will turn red at the anode as	1	

	The concentration of OH^- decreases resulting in that portion being more acidic while The universal indicator at cell 2 will remain green as there is no change in acidity. / In cell 1, OH^- and Cu^{2+} are preferientially discharged, leaving behind sulfuric acid / H^+ and SO_4^{2-}, causing the indicator to turn red while In Cell 2, there is no net change in the conc. of Cu^{2+}, hence the indicator remains green	1 1 1	
A6 (a) (i) (ii) (iii) (iv)	 $CH_3OH + 1.5O_2 \rightarrow CO_2 + 2H_2O$ % of carbon in methanol = 12 / (12+3+16+1)*100% = 37.5% % of carbon in methane = 12 / (12+3+1)*100% = 75.0% Since there is a greater percentage of carbon in methane, therefore, it will form a sootier product. 726 / 32 = 22.7 kJ/g  	 [1] [1] [1] [1] [1] 1m for correct shape for both graphs 1m for labelling E_a and ΔH 1m for $E_{a1}<E_{a2}$ and $\Delta H_1>\Delta H_2$	
(b)	Advantage: Methane and hydrogen both produce greater amounts of energy per gram compared to petrol. Disadvantage: Methane and hydrogen both exist as gas at room temperature and thus require more storage compared to petrol.	[1] [1]	
c			
A7 (a)	Disagree. Increasing concentration of NO increases the rate to a greater extent than increasing the concentration of H_2. Comparing experiment 1 and 2 where concentration of NO was kept constant at 0.0060 mol dm^{-3}, increasing the concentration of H_2 by 2 times from 0.0010 to 0.0020 mol dm^{-3} increases the rate of reaction by 2 times.	[1] [1] [1]	

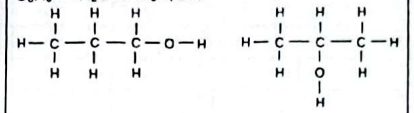
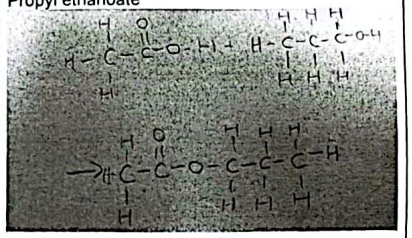
	Comparing experiment 3 and 4 where concentration of H_2 was kept constant at 0.0060 mol dm^{-3}, increasing the concentration of NO by 2 times from 0.0010 to 0.0020 mol dm^{-3} increases the rate of reaction by 4 times.		
(b)	2.4×10^{-4}	[1]	
(c)	At lower temperature, the reacting **NO and H_2 molecules** have **less kinetic energy** and move slower / collide less frequently [;] Less reacting molecules collide with **energy more than or equal to the activation energy** [;] Hence the frequency of **effective collisions** between NO and H_2 decreases[;] 3; [2]	[1] [1] [1]	

P2 Section B:

	Suggested answers	marks	Remarks
B8a	$Ca(HCO_3)_2$ $CaCO_3 (s) + CO_2 (aq) + H_2O (l) \rightarrow Ca(HCO_3)_2 (aq)$	[1] [1]	
b	Limescale (Calcium carbonate) is an **ionic compound** whose **ions are held in a fixed crystal lattice by strong electrostatic forces of attraction** at room temperature and pressure. There are **no free-moving ions** to carry charges and conduct electricity.	[1] [1]	
c	Vinegar **contains ethanoic acid / is acidic / is a weak acid.** It reacts limescale to form **salt, water and carbon dioxide gas.**	[1] [1]	
d	Sample B contains water with higher hardness. It requires **more soap** for lather to form indicating a **higher concentration / more calcium ions**	[1] [1]	
e	When sodium carbonate is added, **insoluble calcium carbonate** is precipitated out. This **decreases the concentration of calcium ions** in the water.	[1] [1]	
f	Add **sodium hydroxide** to the water from the softener until in excess. A **white precipitate is formed which is insoluble in excess** if the water softener has stopped working.	[1] [1]	

	Suggested answers	Marks	Remarks
B9 a (i)	Distilled water contains only water molecules. No mobile ions or electrons to conduct electricity / non-electrolyte.	[1]	
(ii)	X, magnesium, Y and copper	[1]	
b (i)	A and D	[1]	
(ii)	A grey solid is formed and green solution becomes colourless over time for both iron(II) chloride and iron(II) sulfate.	[1]	
	a white precipitate is formed in iron(II) chloride. no visible reaction / no colour change in iron(II) sulfate.	[1]	
	no visible reaction / no colour change in iron(II) chloride. a white precipitate is formed in iron(II) sulfate.	[1]	
	A green precipitate is formed and is insoluble in excess NH_3 for both iron(II) chloride and iron(II) sulfate.	[1]	
B10 a	Addition polymerisation.	[1]	
	Both monomers are unsaturated/ contain C=C	[1]	
b (i)	 *2	[1 for correct repeating unit] [1 for 2 repeating units]	
(ii)	Polymerisation is random/ Styrene can add to another styrene resulting in polystyrene./ Butadiene can also polymerise into polybutandiene./ If styrene and butadiene were to polymerise randomly, the chain will be irregular such as styrene – styrene – butadiene - …	[1]	
(iii)	Moles of carbon dioxide = 24 /44 = 0.5455 mol Therefore, number of moles of styrene-butadiene = 0.5455 / 12 = 0.04546 mol	[1]	
	Since 0.04546 mol => 1kg, 1 mole of styrene-butadiene has a relative mass of 22000g	[1]	
	One repeating unit of styrene-butadiene has an M_r of 158. Therefore, styrene-butadiene has 22000/158 = 139	[1]	

(c)	$C_4H_{10} \rightarrow C_4H_6 + 2H_2$	[1]	
	Rocket fuel / manufacture of ammonia in Haber process / fuel cell / convert alkene to alkane (hydrogenation)	[1]	

	Suggested answers	marks	Remarks
O10 a (i)	Steam / water	1	
	$C_3H_6 + H_2O \rightarrow C_3H_7OH$	1	
(ii)		1m each	
iii	Mole of propanol in a bottle = 0.7 * 40 / 60 = 0.4669	1	
	Mole ratio of propanol to propene = 1:1 = 0.4669: 0.4669	1	
	Volume of propene required = 0.4669* 24dm³ = 11.2 dm³	1	
(b) (i)	Propyl ethanoate	1	
(ii)		1m for correct reactants 1m for correct products	