ST JOSEPH'S INSTITUTION
PRELIMINARY EXAMINATION 2023
(YEAR 4)

CANDIDATE NAME	
CLASS	
INDEX NUMBER	

CHEMISTRY **6092/02**

Paper 2 **18 August 2023**

Candidates answer on the Question Paper.
No Additional Materials are required.

1 hour 45 minutes
(10:45 – 12:30)

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black fluid ink pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

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

Section B
Answer all **three** questions. The last question is in the form either/or.
Answer **all** questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

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

A copy of the Periodic Table is printed on **page 2**.

For Examiner's Use	
Section A	**/ 50**
Section B	**/ 30**
Total	**/ 80**

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Section A (50 marks)

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

A1 The names of some aqueous salts are shown below.

aluminium sulfate

ammonium chloride

calcium chloride

magnesium sulfate

silver nitrate

sodium iodide

zinc nitrate

Use the names of the salts to answer the following questions. You may use each salt once, more than once or not at all.

(a) Which salt(s) undergo a redox reaction when reacted with bromine gas?

…………………………………………………………………………………………..[1]

(b) Which two salts react with each other to form a yellow precipitate?

…………………………………………………………………………………………..[1]

(c) Which salt(s) form a precipitate which is soluble in excess aqueous sodium hydroxide?

…………………………………………………………………………………………..[1]

(d) Which salt(s) form an alkaline gas when heated with excess aqueous sodium hydroxide and aluminium foil?

…………………………………………………………………………………………..[1]

[Total: 4]

A2 'Lean burn' engines are a type of car engine.

Table 2.1 shows some information about lean burn engines compared to normal car engines.

Table 2.1

type of engine	**amount of air mixed with petrol**	**operating temperature**	**concentration of CO in exhaust gases**	**concentration of nitrogen oxides in exhaust gases**
normal	less air	higher	higher	higher
lean burn	more air	lower	lower	lower

(a) Suggest why lean burn engines produce lower amounts of carbon monoxide.

....

....[1]

(b) **(i)** State one natural process that forms nitrogen oxides.

....[1]

(ii) Explain why and how lean burn engines produce lower amounts of nitrogen oxides.

....

....

....[2]

[Total: 4]

A3 Table 3.1 shows some properties of the elements in Group III of the Periodic Table.

Table 3.1

element	proton number	melting point / °C
B	5	2306
A*l*	13	660
Ga	31	30
In	49	157
T*l*	81	304
Nh	113	

(a) Nihonium, Nh, has only recently been discovered.

It has not been possible to directly measure nihonium's melting point, as it is very radioactive.

Suggest why it is also difficult to estimate nihonium's melting point using the data provided in Table 3.1.

....

....[1]

(b) Aluminium and sodium are Period 3 elements.

Aluminium has an electrical conductivity of 3.50×10^7 Siemens per meter (S/m), while sodium has an electrical conductivity of 2.15×10^7 S/m.

Explain why aluminium has a different electrical conductivity from sodium.

....

....[1]

(c) Boron reacts with chlorine gas to form boron trichloride, BCl_3.

Boron trichloride has a melting point of -107 °C.

In boron trichloride, the boron atom does not have a fully-filled valence electron shell.

(i) Draw a 'dot-and-cross' diagram to show the bonding in boron trichloride. Show valence electrons only.

[2]

(ii) Using ideas about structure and bonding, explain why boron has a much higher melting point than boron trichloride.

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…………………………………………………………………………………………[3]

[Total: 7]

A4 Fig. 4.1 shows a simple cell, which can be used to generate electrical energy.

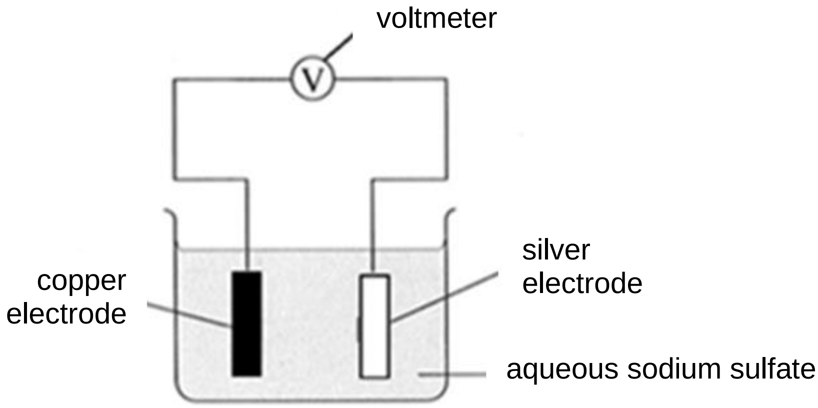

Fig. 4.1

(a) Write an ionic equation for the reaction at the silver electrode.

Hence, using ideas about electron transfer, explain if oxidation or reduction occurs at the silver electrode.

....

....

....[2]

(b) State one change that can be observed in the electrolyte.

....[1]

(c) John replaced the copper electrode with a lead electrode.

(i) A higher voltmeter reading was immediately observed across the lead-silver cell. Explain why.

....

....[1]

(ii) John also tested the electrical conductivity of the electrolyte.

He realised that using a lead-silver cell caused the electrical conductivity of the electrolyte to decrease over time. Explain why.

....

....

....[2]

[Total: 6]

A5 This question is about metals.

(a) The statements below describe metal **X**.

- **X** does not react with cold water.
- **X** fizzes slowly with dilute hydrochloric acid.
- **X** does not react with aqueous sodium chloride.
- **X** reacts with aqueous lead(II) nitrate and aqueous silver nitrate.

(i) Arrange the following metals in order of reactivity.

lead, magnesium, silver, sodium, **X**

most reactive ……………………..………………………

……………………..……………………………

…………………………………..………………

…………………………………..………………

least reactive ……………………………………………….. [1]

(ii) Suggest a possible identity for metal **X**.

………………..……………………..[1]

(iii) Using your answer in **(a)(ii)**, write a chemical equation for the reaction between metal **X** and copper(II) oxide.

[1]

(iv) Explain your answer in **(a)(iii)**.

……………..……………………………………………………………………

………………..……………………..[1]

(b) Iron is a transition element while potassium is a Group I element.

(i) State one difference in physical property between iron and potassium.

………………………………………………………………………………………

……………………………………………………………………………………[1]

(ii) Zinc is used to galvanise iron to prevent the iron from rusting.

Explain how galvanising prevents iron from rusting.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………[2]

(c) Some samples of carbonates are heated strongly until there is no further change in mass.

Table 5.1 shows the mass of solid remaining at the end of heating.

Table 5.1

carbonate	**mass before heating / g**	**mass after heating / g**
calcium carbonate	2.00	1.12
magnesium carbonate	2.00	0.95
iron(II) carbonate	2.00	1.24
zinc carbonate	2.00	1.30

(i) Which carbonate is the most thermally stable?

……………………………………………………………………………………[1]

(ii) Explain why the mass of carbon dioxide formed is different for each carbonate.

………………………………………………………………………………………

……………………………………………………………………………………[1]

[Total: 9]

A6 **(a)** Hydrogen sulfide gas, H_2S, dissolves in water to form aqueous hydrogen sulfide, a weak acid.

(i) When hydrogen sulfide gas is passed through copper(II) sulfate solution, a black precipitate of copper(II) sulfide and dilute sulfuric acid is formed.

Write a chemical equation with state symbols for this reaction.

[2]

(ii) Aqueous hydrogen sulfide reacts with aqueous potassium hydroxide to form potassium sulfide salt.

By using a suitable indicator, describe how pure and dry crystals of potassium sulfide can be prepared using the reactants provided.

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....

....

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....

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....[4]

(b) Two acid-alkali titrations are carried out. A data-logger is used to record the pH of the solutions at regular intervals.

All solutions used in the titrations have a concentration of 0.1 mol/dm^3.

In **titration 1**, aqueous calcium hydroxide is added from a burette into a conical flask containing 30 cm^3 of ethanoic acid.

In **titration 2**, another aqueous alkali is added from a burette into a conical flask containing 30 cm^3 of hydrochloric acid.

Fig. 6.1 shows how the pH varies with the volumes of solution added from the burette in both titrations.

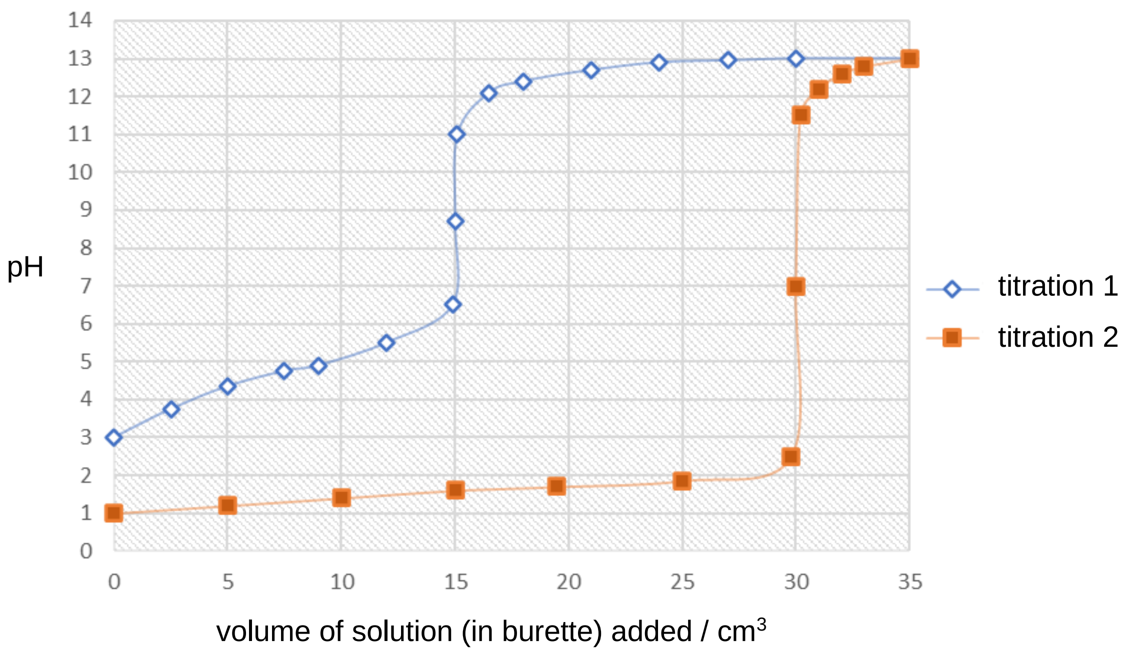


Fig. 6.1

(i) The initial pH of the solution in the flask is measured before any addition of solution from the burette.

Explain why the initial pH values differ in titration 1 and titration 2.

....

....[1]

(ii) Suggest the identity of the alkali used in titration 2.

....[1]

(iii) In a separate titration (**titration 3**), 0.1 mol/dm^3 solution of dilute sulfuric acid is added from a burette to a conical flask containing 30 cm^3 of 0.1 mol/dm^3 aqueous ammonia, as shown by the following equation:

$$H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$$

On the axis provided in Fig. 6.1, sketch how the pH varies with the volume of solution added from the burette.

Label your graph as **titration 3**. [2]

[Total: 10]

A7 **(a)** Petroleum is a mixture of hydrocarbons which can be separated into fractions.

Complete Table 7.1.

Table 7.1

name of fraction	**use of fraction**
	making petrochemical products
gasoline	
	a source of waxes and polishes

[3]

(b) Fractions of crude oil can be processed by cracking.

Give **two** reasons why cracking is important in the industry.

....

....

....

....

....[2]

(c) Fig. 7.1 shows the structures of three organic compounds, **A**, **B**, and **C**.

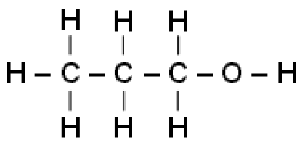
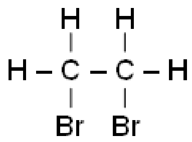
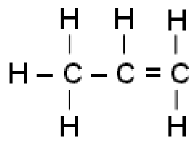
A	**B**	**C**
		

Fig. 7.1

(i) Compound **A** reacts with methanoic acid to form compound **D**.

Draw the full structural formula of **D**.

[1]

(ii) Compound **E** is an isomer of compound **D**. An aqueous solution of **E** has a pH of 3.

Draw the full structural formula of **E**.

[1]

(iii) Compound **B** is formed by reacting ethane with bromine in the presence of ultraviolet light.

Write a balanced chemical equation for this reaction.

[1]

(iv) Compound **C** can undergo addition polymerisation.

Draw the structural formula of **two** repeating units of the addition polymer formed from **C**.

[1]

(v) Describe and explain why discarding the addition polymer of **C** in water bodies should be discouraged.

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………………………………………………………………………………………

……………………………………………………………………………………[1]

[Total: 10]

Section B (30 marks)

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.

B8 Determining rates of reaction using concentration-time graphs

Fig. 8.1 shows a concentration vs. time graph when magnesium is added to dilute nitric acid. The gradient of the graph gives the rate of reaction at that point of time.

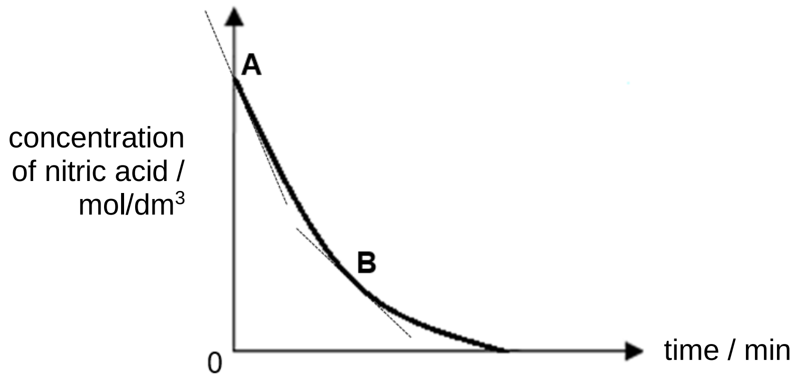

Fig. 8.1

Determining the order of reaction of reactants

Changing the concentration of different reactants can have different effects on the rate of reaction. The **order of reaction** with respect to a reactant describes how the reactant's concentration affects the rate of reaction.

Consider the reaction between phenylamine, $C_6H_5NH_2$, and bromine.

$$C_6H_5NH_2 + 3Br_2 \rightarrow C_6H_2NH_2Br_3 + 3HBr$$

Table 8.1 shows the initial rates of this reaction when varying concentrations of both reactants are used in experiments 1 to 3.

Table 8.1

experiment	concentration of $C_6H_5NH_2$ in mol/dm^3	concentration of Br_2 in mol/dm^3	initial rate of reaction in mol/(dm^3 s)
1	0.001	0.001	0.007
2	0.001	0.002	0.014
3	0.002	0.002	0.056

Comparing experiments 1 and 2, when the concentration of Br_2 doubles, the initial rate of reaction doubles too. The initial rate of reaction is directly proportional to the concentration of Br_2. Hence, the reaction is **first order** with respect to Br_2.

Comparing experiments 2 and 3, when the concentration of $C_6H_5NH_2$ doubles, the initial rate of reaction increases by four times (i.e. by 2^2 times). The initial rate of reaction is directly proportional to the **square** of the concentration of $C_6H_5NH_2$. Hence, the reaction is **second order** with respect to $C_6H_5NH_2$.

The reaction can also be **zero order** with respect to a reactant. In this case, changing the concentration of this reactant will have no impact on the rate of reaction.

The acid-catalysed reaction of propanone and iodine

The order of reaction of reactants can also be determined in reactions where three substances are involved. Table 8.2 shows the initial rates of reaction when varying concentrations of propanone, CH_3COCH_3, and aqueous iodine react together in the presence of dilute sulfuric acid catalyst.

$$CH_3COCH_3 + I_2 \xrightarrow{H^+} CH_3COCH_2I + HI$$

Table 8.2

experiment	concentration of CH_3COCH_3 in mol/dm^3	concentration of I_2 in mol/dm^3	concentration of H^+ in mol/dm^3	initial rate of reaction in mol/(dm^3 s)
A	0.6	0.0002	0.2	3.2×10^{-6}
B	0.6	0.0002	0.4	6.4×10^{-6}
C	1.8	0.0002	0.2	9.6×10^{-6}
D	1.2	0.0002	0.2	?
E	0.6	0.0004	0.2	?

During experiments **A** and **E**, the concentrations of iodine in the reaction mixtures were monitored. This is shown in Fig. 8.2, where both graphs were found to be parallel.

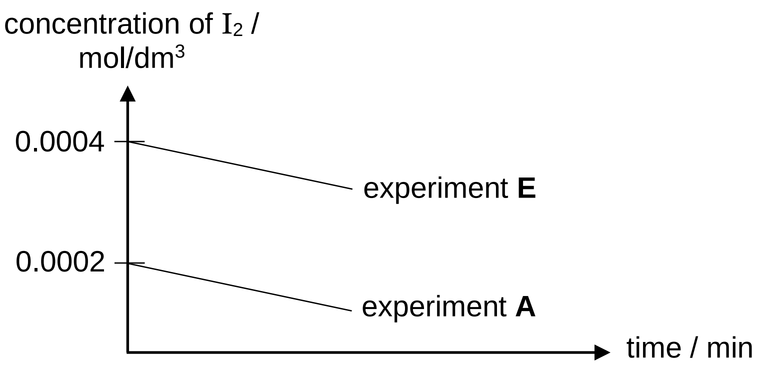

Fig. 8.2

(a) **(i)** Using Fig. 8.1, state and explain how the reaction rate at **B** compares with the reaction rate at **A**.

………………………………………………………………………………………

……………………………………………………………………………………[1]

(ii) A student claimed that magnesium is added in excess to dilute nitric acid.

Do you agree? Explain your reasoning.

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………………………………………………………………………………………

……………………………………………………………………………………[1]

(b) **(i)** The reaction between propanone and iodine is catalysed by dilute acid.

Explain, in terms of collisions and energy, why using a catalyst increases the rate of this reaction.

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………………………………………………………………………………………

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………………………………………………………………………………………

……………………………………………………………………………………[2]

(ii) Identify the reducing agent in the acid-catalysed reaction of propanone and iodine.

Explain your answer using oxidation states.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………[2]

(c) **(i)** The acid-catalysed reaction of propanone and iodine is first order with respect to propanone.

Use information from Table 8.2 to explain why the reaction is first order with respect to propanone.

Clearly identify which experiments you are comparing.

....

....

....

....

....[2]

(ii) Hence, calculate the rate of reaction of experiment **D** in mol/(dm^3 s).

[1]

(d) **(i)** State the rate of reaction of experiment **E** in mol/(dm^3 s).

Explain your answer using information from Fig. 8.2 and Table 8.2.

....

....

....[2]

(ii) Hence, state the order of reaction with respect to iodine.

....[1]

[Total: 12]

B9 Carpet fibre can be made by the polymer polytrimethylene terephthalate (PTT).

Fig. 9.1 shows **one** repeating unit of PTT.

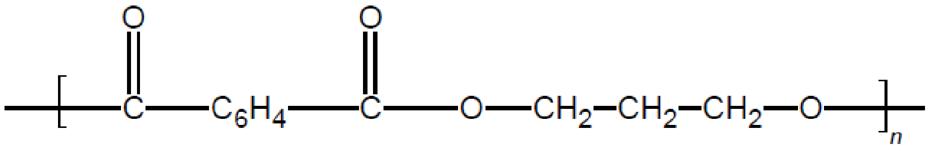

Fig. 9.1

Carpet fibre can also be made by the natural rubber polymer, poly(isoprene), which can be extracted from rubber trees.

Fig. 9.2 shows **two** repeating units of poly(isoprene).

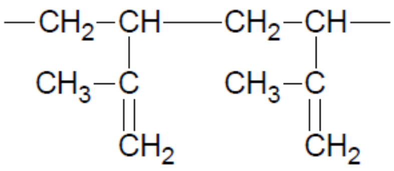

Fig. 9.2

(a) Draw the structures of the monomers used to form PTT and poly(isoprene).

Monomers used to form PTT

Monomer used to form poly(isoprene)

[3]

(b) **(i)** Calculate the number of moles of repeating units present in:

- 1.0 kg of PTT, and
- 1.0 kg of poly(isoprene).

[2]

(ii) Hence, using suitable calculations or otherwise, explain how and why burning 1.0 kg of poly(isoprene) contributes more to global warming than burning 1.0 kg of PTT.

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………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………[2]

(iii) Calculate the number of repeating units present in 1.0 kg of PTT.

[1]

[Total: 8]

EITHER

B10 **(a)** Octane, C_8H_{18}, is used as a fuel in cars.

An alternative fuel for cars is hydrogen, which can be used in a fuel cell.

Table 10.1 shows some information about octane and hydrogen.

Table 10.1

fuel	**melting point / °C**	**boiling point / °C**	**enthalpy change of combustion in kJ/mol**
octane	-57	125	-5075
hydrogen	-259	-253	-286

(i) Using ideas about breaking and forming bonds, explain why the enthalpy change values for **both** combustion reactions are negative.

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………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………[2]

(ii) Calculate the enthalpy change when 1 kg of each fuel is completely combusted.

[2]

(iii) Evaluate the use of octane and hydrogen as fuels in cars using Table 10.1, and the values you calculated in **(a)(ii)**. Your answer should consider:

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

....

....

....

....

....

....[2]

(iv) Some people think that hydrogen is a completely non-polluting fuel.

Explain why this is incorrect.

....

....

....[1]

(b) Chlorofluorocarbons (CFCs) like CF_2Cl_2 deplete the ozone layer.

(i) Explain, in terms of human health, why it is important to slow down the depletion of the ozone layer.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(ii) The first step of ozone depletion happens when energy from sunlight breaks a bond in a CFC molecule.

The bond energy of the C–F bond in CF_2Cl_2 is 485 kJ/mol.
The bond energy of the C–Cl bond in CF_2Cl_2 is 327 kJ/mol.

Explain why the ozone layer contains more chlorine atoms than fluorine atoms.

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……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

[Total: 10]

OR

B10 **(a)** A student added three metal strips to dilute sulfuric acid separately.

Table 10.1 shows his observations.

Table 10.1

metal	**reaction with dilute sulfuric acid**
chromium	moderate effervescence, dark green solution of chromium(III) sulfate formed
iron	slow effervescence, pale green solution of iron(II) sulfate formed
manganese	rapid effervescence, pale pink solution of manganese(II) sulfate formed

The student then adds strips of chromium and manganese into salt solutions containing iron(II) and manganese(II) ions.

(i) Complete the table below.

test	**metal**	**solution**	**initial colour of solution**	**final colour of solution**
1	chromium	iron(II) sulfate		
2	manganese	iron(II) sulfate	pale green	pale pink
3	chromium	manganese(II) sulfate		

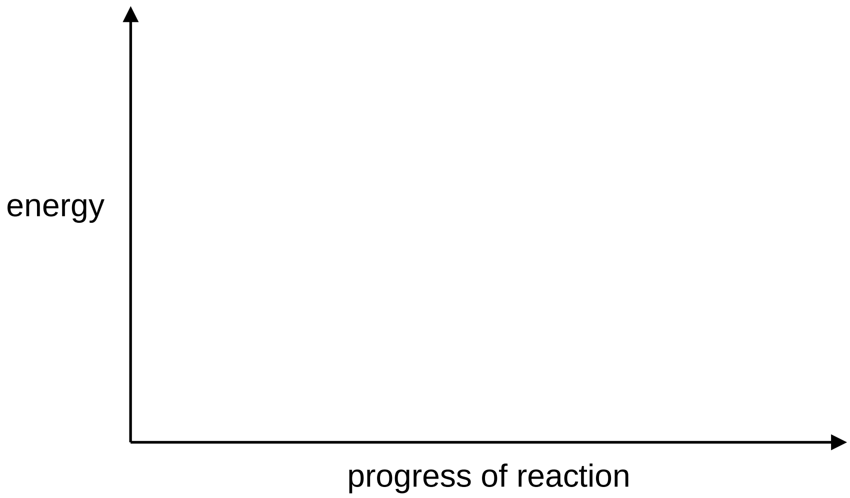
[2]

(ii) Displacement reactions are exothermic.

Sketch the energy profile diagram for the reaction between chromium and iron(II) sulfate.

Your diagram should include:

- the names of the reactants and products of the reaction,
- labels to show the enthalpy change of reaction and activation energy.



[3]

(b) Fig. 10.1 shows the set-up used to electrolyse concentrated aqueous sodium chloride. A few drops of purple litmus solution were added to the electrolyte.

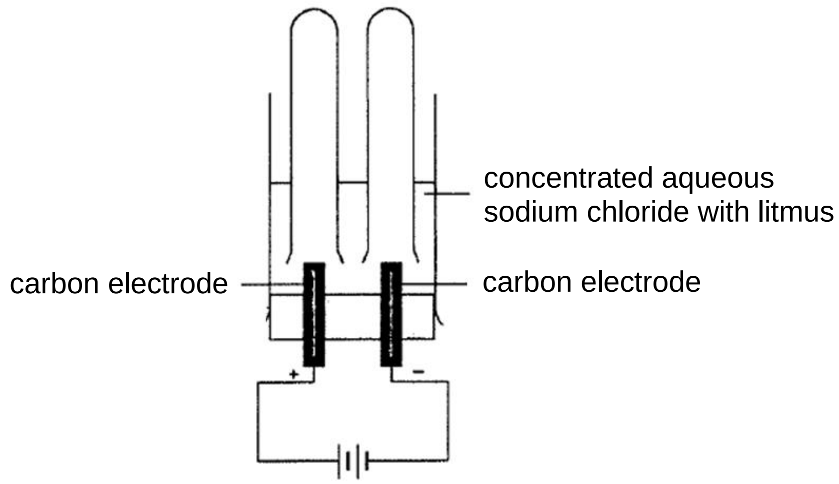


Fig. 10.1

(i) The solution around the anode turned from purple to colourless.

Explain this observation, supporting your answer with an ionic equation.

....

....

....

....[2]

(ii) The pH of the solution around the cathode increased during electrolysis.

Explain why.

....

....

....[1]

(iii) The set-up in Fig. 10.1 can be used to electrolyse dilute sodium chloride.

Give **two** differences between the products of the electrolysis of dilute and concentrated aqueous sodium chloride.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………….[2]

[Total: 10]

- End of Paper -