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Grade 12 Physical Science 2024

Preliminary Examination Paper 2 (Chemistry)

11 September 2024

200 Marks

3 hours

Full Name:

INSTRUCTIONS:

1. This paper consists of 31 pages.
2. Write in dark blue or black pen.
3. **Graphs and diagrams must be drawn in pencil.**
4. The use of a non-programmable calculator is permitted.
5. Answer all questions in the spaces provided on the question paper.
6. You should show all your working on the question paper.
7. Where appropriate, express answers to TWO decimal places.
8. The number of marks is given in brackets () at the end of each question.
9. TWO blank pages (pages 30 and 31) are included at the end of the paper. If you run out of space for a question, use these pages. Clearly indicate the question number of your answer should you use

For Examiner's Use <i>Mr. K. Bennett</i>		For Moderators's Use <i>Mr. K. Hall</i>	
Question	Mark	Question	Mark
1	/20	1	/20
2	/12	2	/12
3	/8	3	/8
4	/23	4	/23
5	/23	5	/23
6	/27	6	/27
7	/21	7	/21
8	/21	8	/21
9	/33	9	/33
10	/12	10	/12
Total	/200	Total	/200
Initial		Initial	

Question 1 [20 Marks]**MULTIPLE CHOICE**

Answer these questions on the multiple-choice answer sheet below.

Make a cross (X) in the box corresponding to the letter that you consider to be correct.

A	B	C	D
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Here the option C has been marked as an example.

1.1	A	B	C	D
1.2	A	B	C	D
1.3	A	B	C	D
1.4	A	B	C	D
1.5	A	B	C	D
1.6	A	B	C	D
1.7	A	B	C	D
1.8	A	B	C	D
1.9	A	B	C	D
1.10	A	B	C	D

1.1 What is the correct formula for the anion in calcium hydrogencarbonate?

- A** CO_3^{2-}
- B** HCO_3^{3-}
- C** HCO_3^{2-}
- D** HCO_3^-

(2)

1.2 What is the nature of the intramolecular bonding in calcium hydrogencarbonate?

- A** Ionic bonding only
- B** Covalent bonding only
- C** Both ionic bonding and hydrogen bonding
- D** Both ionic bonding and covalent bonding

(2)

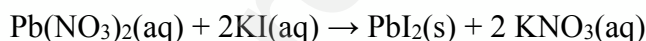
1.3 What bonds are broken/overcome when calcium hydrogencarbonate melts?

- A** Hydrogen bonding only
- B** Ionic bonding only
- C** Covalent bonding only
- D** Both ionic bonding and hydrogen bonding (2)

1.4 Which sample, measured at room temperature and pressure, contains the greatest number of the stated particles?

- A** 1 g of hydrogen molecules
- B** 1 g of helium atoms
- C** 1 dm³ of hydrogen molecules
- D** 1 dm³ of helium atoms (2)

1.5 Lead(II) nitrate and potassium iodide react according to the equation



In an experiment, 25.0 cm³ of a 0.10 mol.dm⁻³ solution of each compound are mixed together.

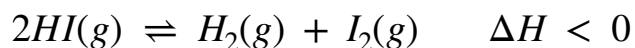
Which amount, in mol, of lead(II) iodide is formed?

- A** 1.25×10^{-3}
- B** 2.50×10^{-3}
- C** 1.25×10^{-2}
- D** 2.50×10^{-2} (2)

1.6 Which of the following will produce a basic solution when dissolved in water?

- A** lithium sulfite
- B** ammonium chloride
- C** hydrogen chloride
- D** potassium nitrate (2)

1.7 The following system was allowed to reach equilibrium at 300 °C.



Colourless Colourless Purple

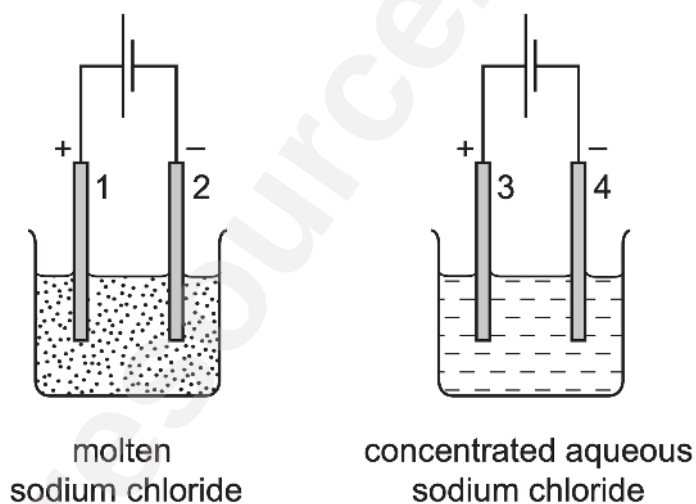
What would you see if the equilibrium mixture was cooled to 250 °C?

- A** no visible change.
- B** the colour gets lighter.
- C** the mixture turns colourless.
- D** the mixture goes a darker purple.

(2)

1.8 Two electrolysis experiments were carried out as shown in the diagram below.

The graphite electrodes are labelled 1 — 4.



Which row describes the products formed at the electrodes in these experiments?

	electrode 1	electrode 2	electrode 3	electrode 4
A	chlorine	hydrogen	chlorine	hydrogen
B	chlorine	sodium	chlorine	hydrogen
C	chlorine	sodium	hydrogen	chlorine
D	sodium	chlorine	sodium	chlorine

(2)

1.9 Copper carbonate reacts with dilute sulfuric acid to make copper sulfate.



Which row gives the correct order of steps for making copper sulfate crystals?

	step 1	step 2	step 3	step 4
A	add excess acid to the copper carbonate	filter	evaporate filtrate to point of crystallisation	leave to cool
B	add excess acid to the copper carbonate	filter	evaporate to dryness	leave to cool
C	add excess copper carbonate to the acid	evaporate to point of crystallisation	leave to cool	filter
D	add excess copper carbonate to the acid	filter	evaporate filtrate to point of crystallisation	leave to cool

(2)

1.10 An electrolytic cell was set up using systems **I** and **II**.

I	$\text{V}^{3+}(\text{aq}) + \text{e}^{-} \rightleftharpoons \text{V}^{2+}(\text{aq})$	$E^{\circ} = -0.26 \text{ V}$
II	$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^{-} \rightleftharpoons \text{Fe}(\text{s})$	$E^{\circ} = -0.44 \text{ V}$

Calculate the cell potential for this cell.

- A** -0.18 V
- B** -0.26 V
- C** -0.44 V
- D** 0.18 V

(2)

Question 2 [12 Marks]**CRYSTALLINE SOLIDS**

2.1 Diamond and iodine are both crystalline solids at room temperature.

Diamond has an extraordinarily high melting point of 4500 °C. In contrast, iodine vapourises into a purple gas when gently heated.

Identify one *similarity* in the **bonding**, and one *difference* in the **structures**, of these two solids. Explain why these solids have very different melting points.

(6)

(1) **calcium oxide**, (2) **graphite** and (3) **magnesium**

Diagrams:

Explanation:.....

edurex

(6)

Question 3 [8 Marks]**FORCES BETWEEN MOLECULES**

The table below shows the electronegativity values of some elements.

	Fluorine	Chlorine	Bromine	Iodine	Carbon	Hydrogen
Electronegativity	4.0	3.0	2.8	2.5	2.5	2.1

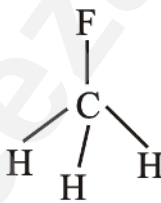
3.1 Define *electronegativity*.

.....

.....

..... (2)

3.2 The table below shows the boiling points of fluorine, fluoromethane (CH_3F) and hydrogen fluoride.

	F–F		H–F
Boiling point/ °C	-188	-79	20

3.2.1 Name the strongest type of intermolecular force present in:

Liquid F_2 :

Liquid CH_3F :

Liquid HF: (3)

3.2.2 Explain how the strongest type of intermolecular force in liquid HF arises.

.....

.....

.....

.....

.....

.....

..... (3)

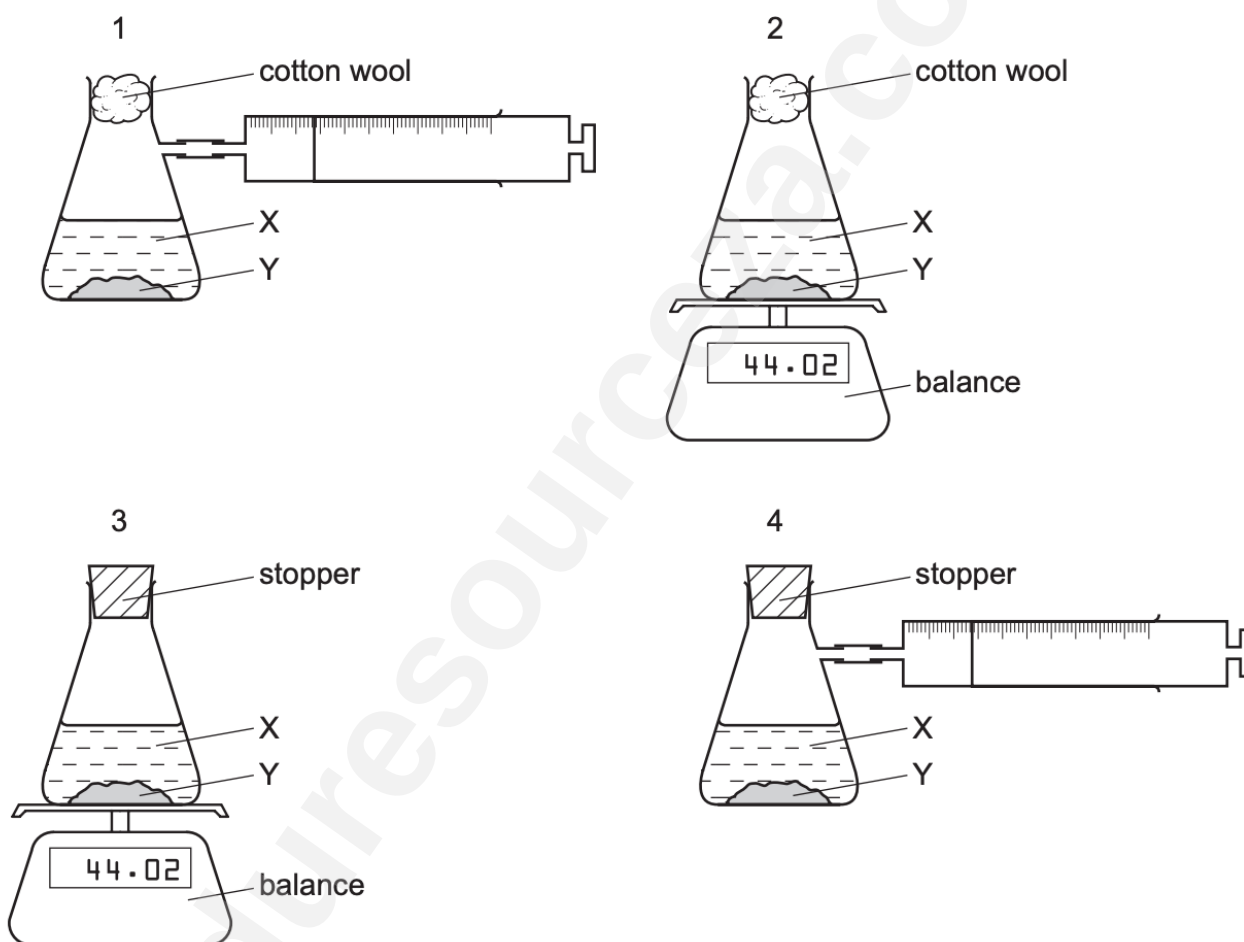
Question 4 [23 Marks]**RATES OF REACTION**

Hydrogen peroxide decomposes to form water and oxygen. This reaction is catalysed by manganese(IV) oxide (MnO_2).



40 cm³ of aqueous hydrogen peroxide (**X**) was put in the flask and **0.10 g** of **small lumps** of manganese(IV) oxide (**Y**) was added.

4.1 Which two diagrams show suitable methods for investigating the rate of the reaction?



Tick (✓) **one** box

☐ 1 and 3

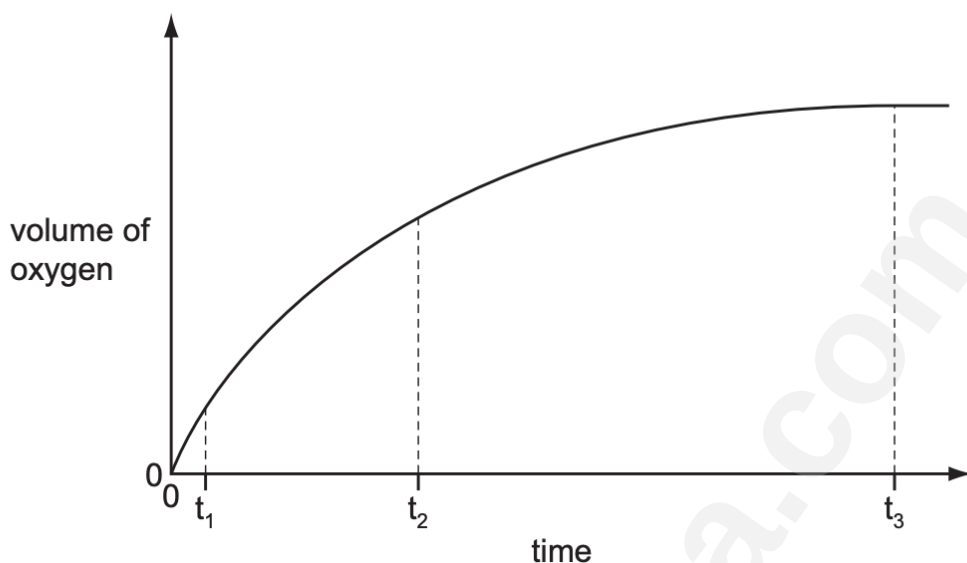
☐ 1 and 4

☐ 2 and 3

☐ 2 and 4

(2)

- 4.2 The volume of oxygen collected was measured every 30 seconds. The results were plotted to give the graph shown below.



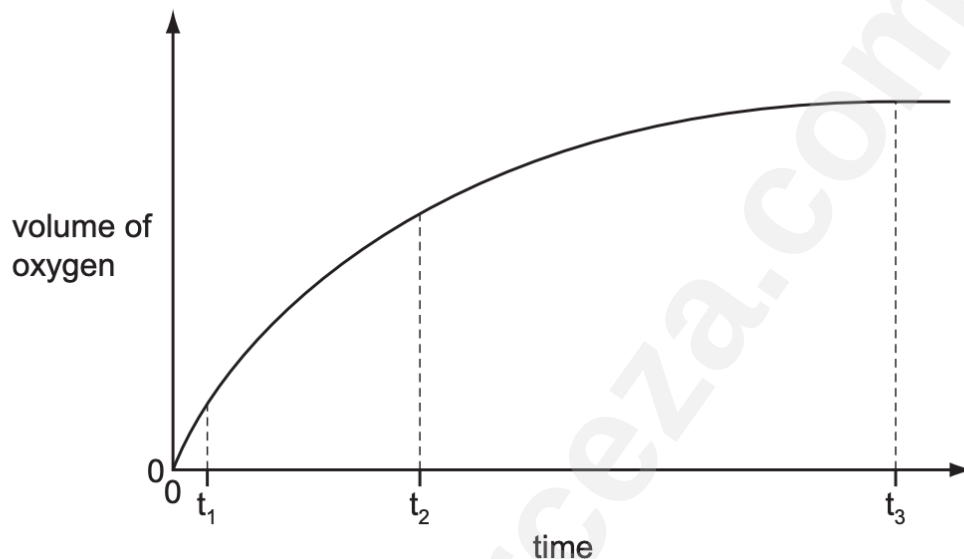
- 4.2.1 How do the rates at times t_1 , t_2 and t_3 differ?

(2)

- 4.2.2 Using collision theory, explain the trend in reaction rate that you described in Question 4.1.1.

(3)

4.3.1 On the axes below, **sketch the graph** that would be expected. (2)



(3)

.....

.....

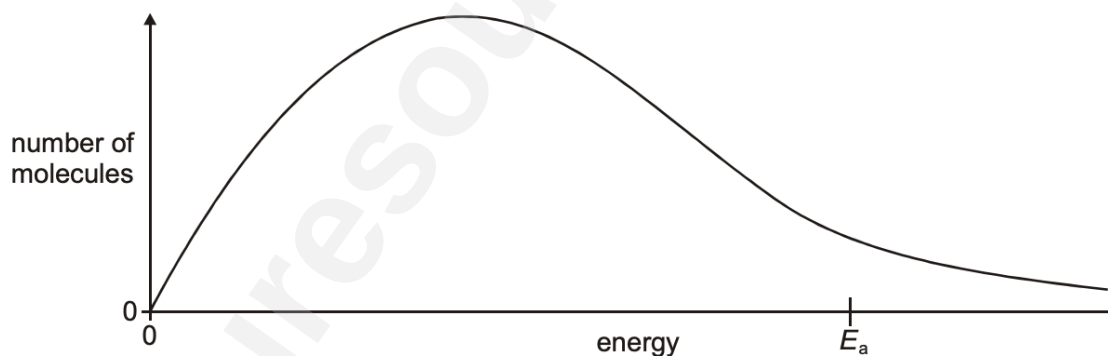
..... (2)

4.4.2 Describe how you could show that the catalyst, manganese(IV) oxide (MnO_2), was not used up in the reaction.

(2)

4.5 Explain how the **concentration** of $\text{H}_2\text{O}_2(\text{aq})$ can increase the rate of its decomposition.

As part of your answer, you should **add a second curve** to the Maxwell-Boltzmann distribution curve of molecular kinetic energies shown below.



(4)

- 4.6 In the first experiment, the maximum volume of oxygen produced was 96 cm³ measured at STP. Calculate the concentration of the aqueous hydrogen peroxide in mol.dm⁻³.



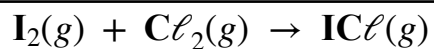
number of moles of O₂ formed = ... (1)

number of moles of H₂O₂ in 40 cm³ of solution = ... (1)

concentration of the aqueous hydrogen peroxide in mol.dm⁻³ = ... (1)

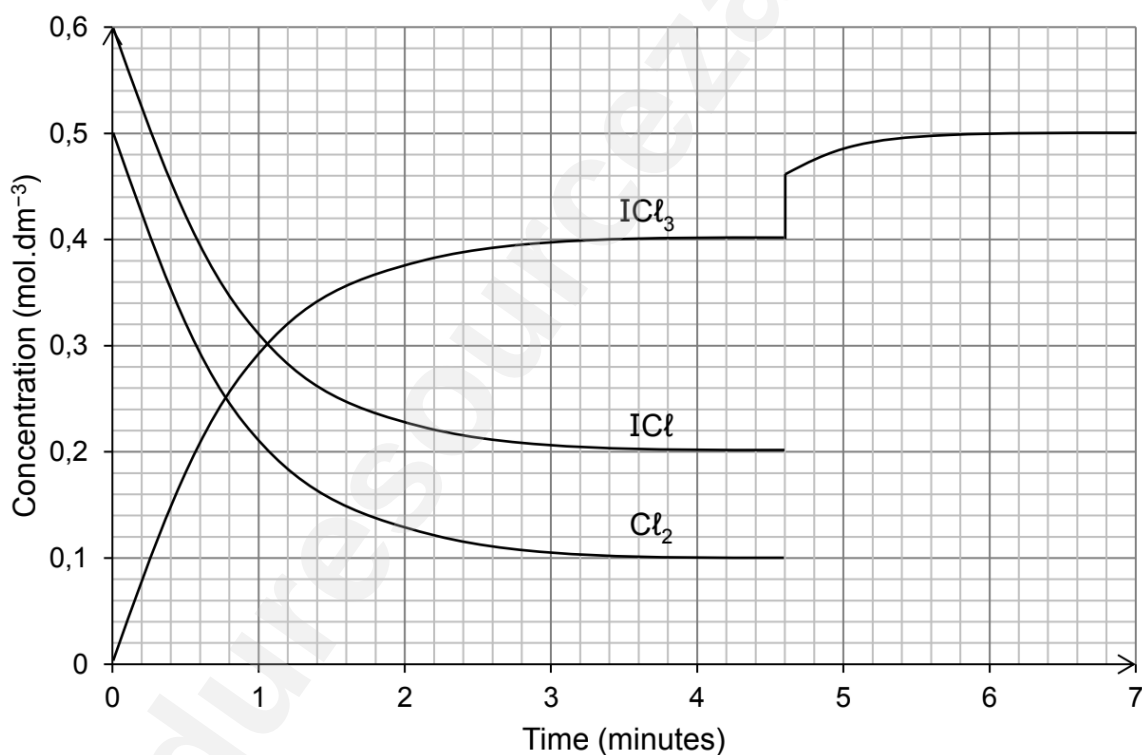
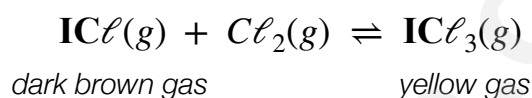
Question 5 [23 Marks]**DYNAMIC CHEMICAL EQUILIBRIUM**

Iodine reacts with chlorine to form iodine monochloride, ICl .



Iodine monochloride (a dark brown gas) can then react with chlorine to form iodine trichloride (a yellow gas). This reaction is investigated at a constant temperature in a **sealed container**.

A dynamic equilibrium mixture is established according to the following equation and the graph below:



5.1 The sealed container creates a closed system. What is meant by a closed system?

.....
 (2)

5.2 Compare the rates of the forward and reverse reactions at $t = 2$ minutes.

..... (1)

5.3 How does this graph indicate that dynamic chemical equilibrium has been reached between 3,9 – 4,6 minutes?

.....
..... (2)

5.4 Give the equilibrium constant expression and then calculate the value of K_c for this equilibrium at $t = 4,4$ minutes.

$K_c =$
(4)

Refer to the graph on Page 15. At $t = 4,6$ minutes, an adjustment **was made to the system** while the temperature remained unchanged. Only the change for the iodine trichloride line is shown, but all three substances underwent a change.

5.5 State Le Châtelier's principle.

.....
.....
.....
.....
..... (2)

5.6 Was the forward or reverse reaction rate increased at $t = 4,6$ minutes?

..... (2)

5.7 Describe the colour of the re-established equilibrium mixture at $t = 7$ minutes.

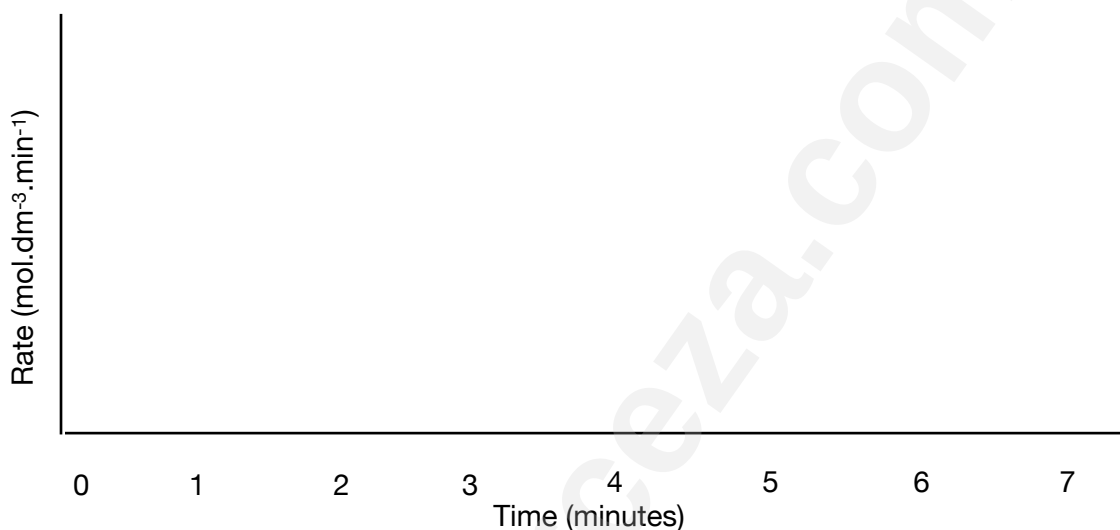
..... (1)

5.8 Use all the information provided on the graph to determine the type and nature (increase or

decrease) of the disturbance to the equilibrium at $t = 4,6$ minutes.

..... (4)

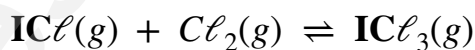
- 5.9 On the graph below, sketch a graph of reaction rate against time for the reaction up to 7 minutes. Label your forward and reverse reactions clearly.



..... (3)

At $t = 7$ minutes, the temperature of the reaction was increased, and the system was allowed to reach equilibrium. At this new equilibrium, the value of the equilibrium constant had decreased.

The equilibrium equation is given below for your ease of reference.

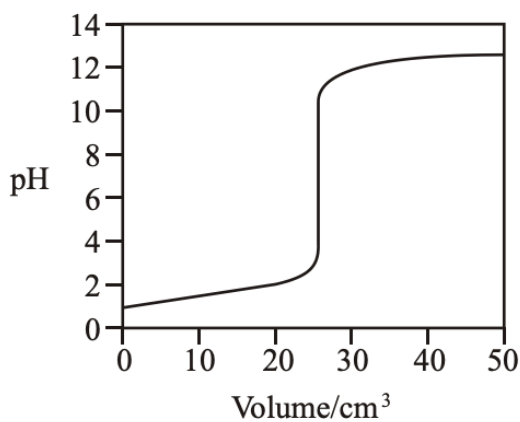
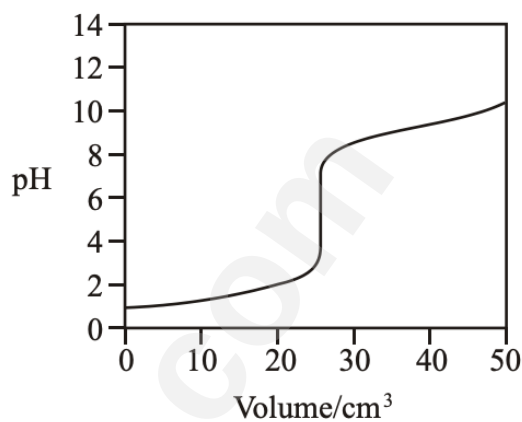
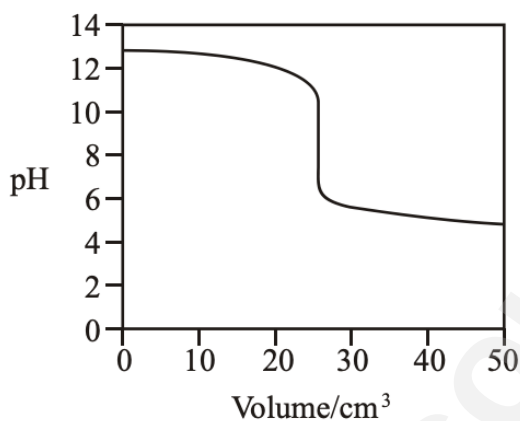
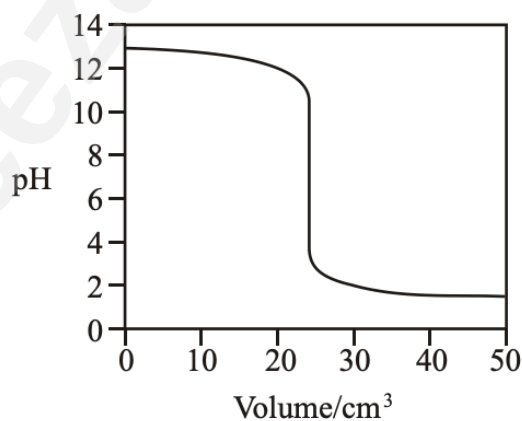


- 5.10 Is the forward reaction EXOTHERMIC or ENDOTHERMIC?
Explain your reasoning.

..... (4)

Question 6 [27 Marks]**ACIDS AND BASES**

6.1 Titration curves labelled A, B, C and D for combinations of different acids and bases are shown below. All solutions have a concentration of 0.1 mol dm^{-3} .

**A****B****C****D**

6.1.1 Ammonia is said to be a *weak base*. Explain what is meant by this statement.

.....

 (2)

6.1.2 Write a balanced chemical equation showing the reaction between ammonia and hydrochloric acid.

..... (2)

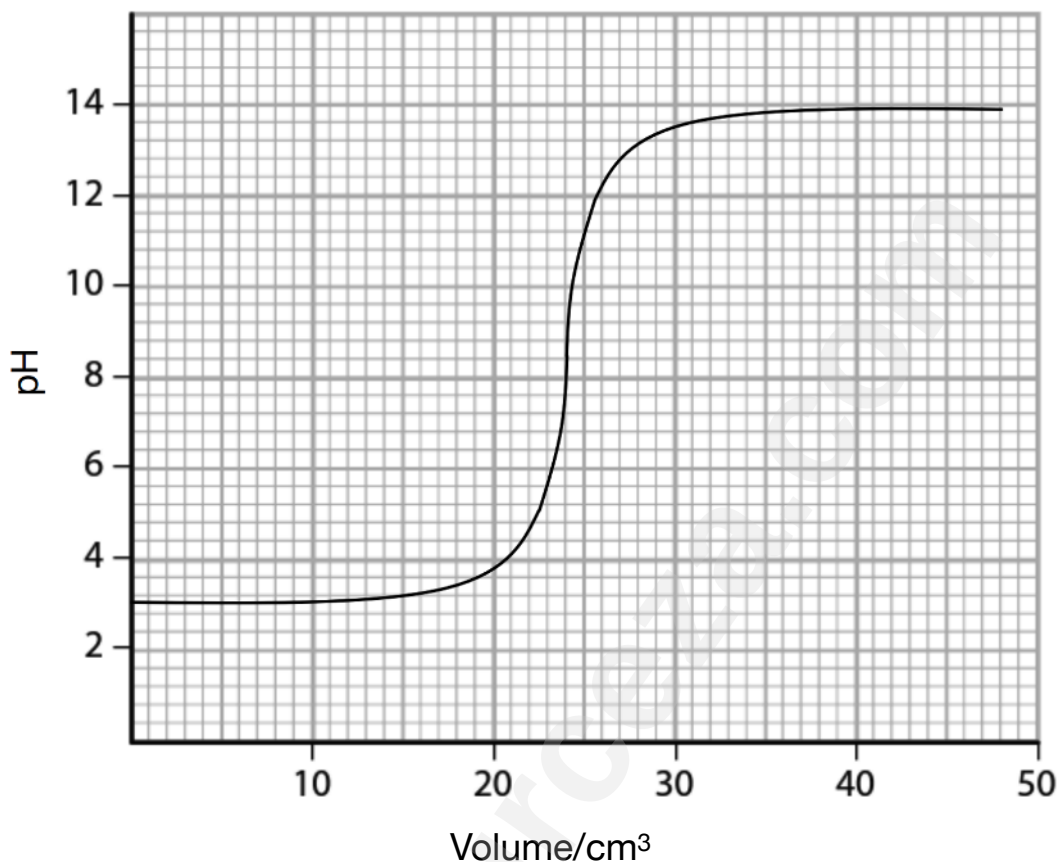
6.1.3 Select from **A**, **B**, **C** and **D** the curve produced by the addition of:

ammonia to 25 cm^3 of hydrochloric acid

ethanoic acid to 25 cm^3 of sodium hydroxide

sodium hydroxide to 25 cm^3 of hydrochloric acid (3)

6.2 The following titration curve was obtained using a pH probe placed in a conical flask during a titration.



6.2.1 Define *equivalence point*.

.....
 (2)

6.2.2 Using the graph, state the pH of the equivalence point: **pH** = ... (1)

6.2.3 The table shows information on 4 indicators:

Name of indicator	pH range
methyl red	4.2 — 6.3
bromothymol blue	6.0 — 7.6
thymol blue	8.0 — 9.8
indigo carmine	11,6 — 13,0

What indicator should be chosen for this titration?

..... (1)

6.2.4 During the titration, the standard solution of acid is placed in the conical flask with the indicator. The base of unknown concentration is placed in the burette. What volume of base is required to neutralise the acid?

..... (1)

6.2.5 The acid has a formula of H_2X (aq).

Write the balanced chemical equation for ionisation of the acid in water.

..... (3)

6.3 At 25 °C, the concentration of the standard solution of acid, H_2X (aq), in the conical flask is 0,34 mol.dm⁻³.

The hydroxide ion concentration in the flask is 2×10^{-11} mol.dm⁻³.

6.3.1 Determine the acid ionisation constant (K_a) of the acid.

(8)

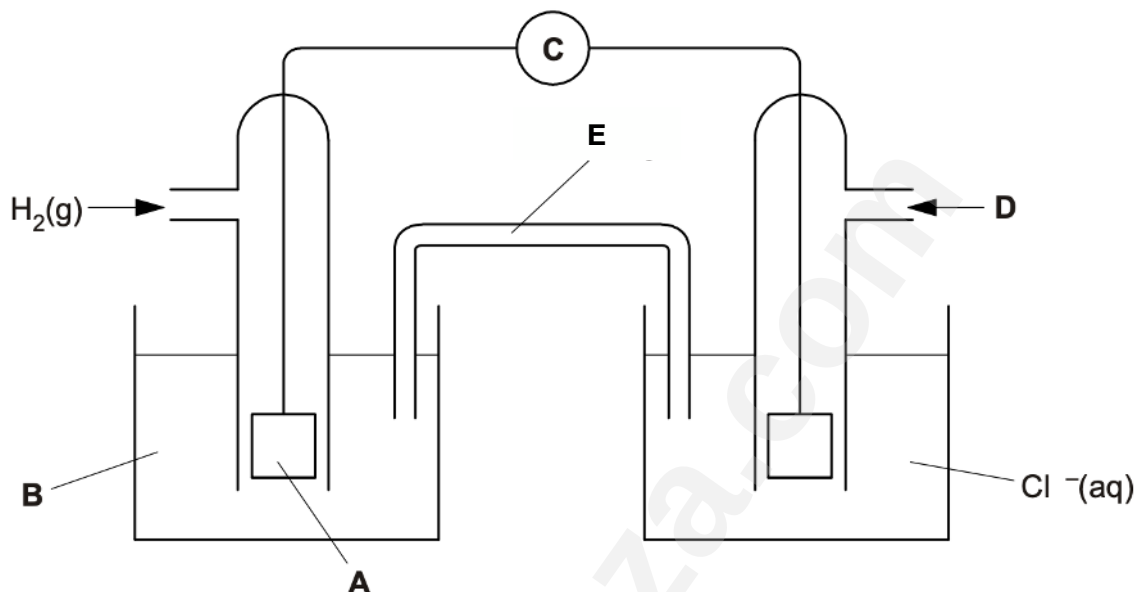
6.3.2 Is H_2X a monoprotic, diprotic or triprotic acid? (1)

6.3.3 Using your answer(s) above, explain if H_2X is a good or poor conductor of electricity.

.....
.....
.....
..... (3)

.Question 7 [21 Marks]**STANDARD ELECTRODE POTENTIALS**

The standard electrode potential of the Cl_2 / Cl^- half-cell may be measured using the following apparatus.



7.1 Electrochemical cells are based on redox chemistry. What is meant by a *redox reaction*?

.....
 (2)

7.2 Suggest suitable labels for **A**, **B**, **C** and **D**.

Metal A:

Electrolyte B:

Apparatus C:

Gas D: (4)

7.3 Suggest **one** function for part **E**.

.....
 (1)

7.4 Assuming the mass remains constant, how would using a gauze (mesh) for A, instead of a solid plate, impact the current flowing through the cell?

Write INCREASE, DECREASE or REMAIN THE SAME.

..... (1)

7.5 The half-cell reactions involved are shown.



The values of E^θ are measured under standard conditions with reference to a hydrogen half cell.

7.5.1 Write down the **cell notation** for the cell used to determine the standard electrode potential of the chlorine half-cell. Include phase indicators and standard conditions.

.....

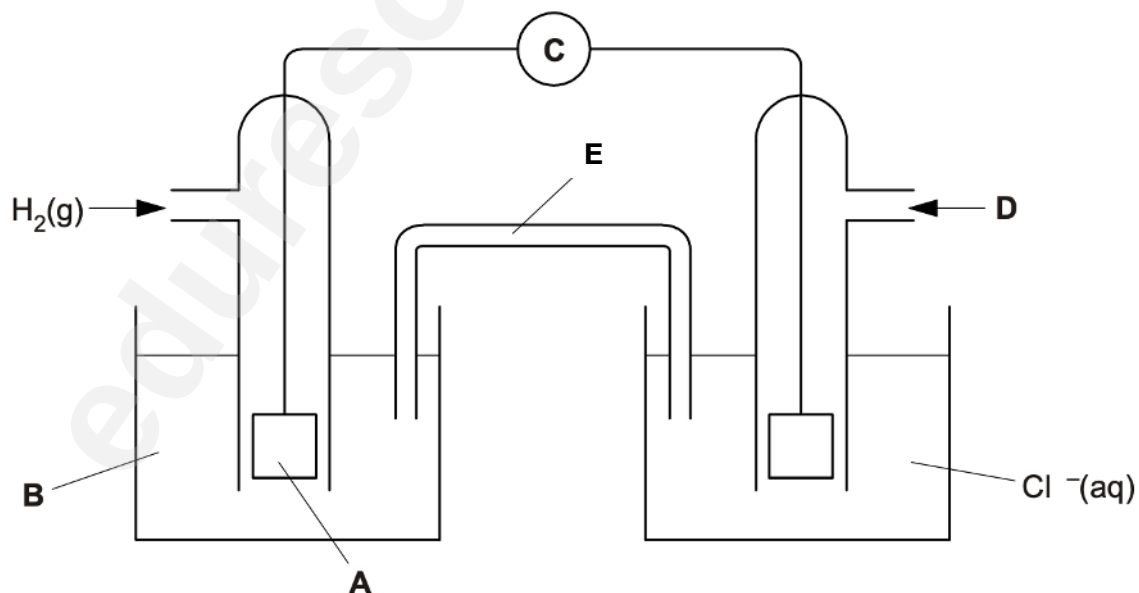
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.....

..... (5)

7.5.2 Use an **arrow** ($\leftarrow$) to show the direction of flow of **electrons** in the diagram of the apparatus below.



(2)

7.5.3 The pressure of the hydrogen gas entering the hydrogen half-cell is increased.

How would this affect the initial EMF of the cell? Fully explain your answer.

.....

.....

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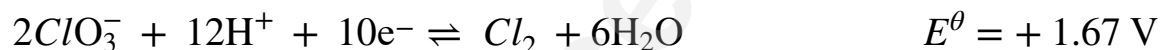
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.....

.....

..... (3)

7.6 The half cell reaction for $\text{ClO}_3^- / \text{Cl}_2$ is shown below.



What does this tell you about the oxidising ability of ClO_3^- compared with Cl_2 ?

Explain your answer.

.....

.....

.....

.....

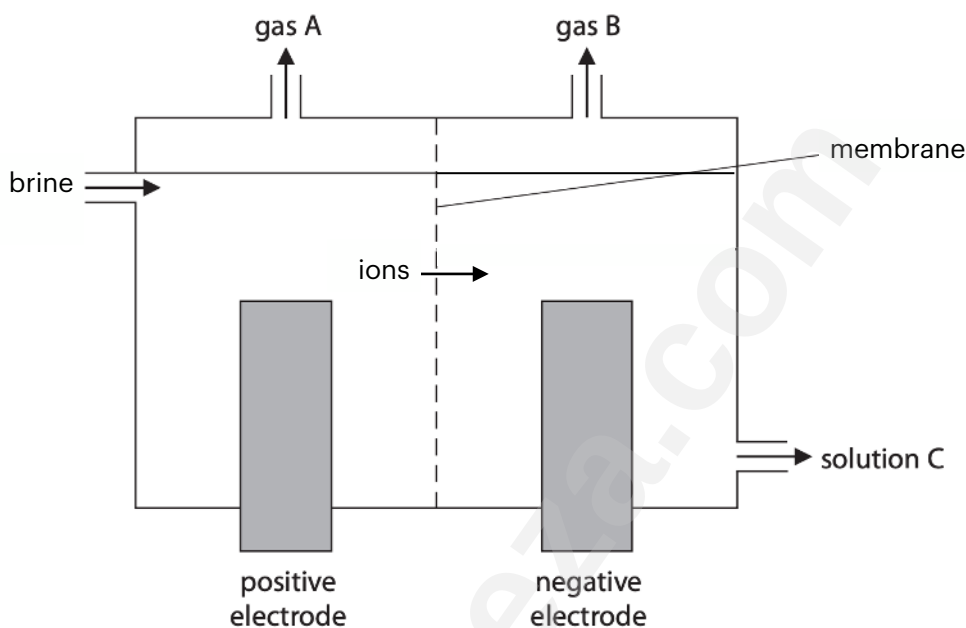
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.....

..... (3)

Question 8 [21 Marks]**CHEMICAL SYSTEMS**

The diagram below is a simplified version of a membrane cell, one of the electrolytic cells used in the chlor-alkali industry. The letters **A** and **B** represent the two gases formed during this process.



8.1 What is brine, the raw material in this process?

..... (1)

8.2 State the energy conversion taking place in this cell.

..... (1)

/

8.3 Identify the ions that can pass through the membrane.

..... (1)

8.4 Identify the species that is reduced at the cathode.

..... (1)

8.5 Write down the **half-reaction** that shows how gas **A** and gas **B** are respectively formed.

Gas A: (2)

Gas B: (2)

8.6 Identify Solution C:

Solution C: (1)

8.7 Write down the net cell reaction.

..... (2)

8.8 Use the relative strengths of the oxidising agents present to explain why sodium metal is NOT produced at the cathode in the membrane cell.

.....
.....
.....
.....
.....
.....
..... (3)

8.9 A **constant current** of 4 000 A is passed through a chlor-alkali cell for 2,5 minutes.
Calculate the volume of chlorine gas produced, at STP, at the anode during this period of time.

(7)

Question 9 [33 Marks]**CRUDE OIL**

Crude oil is a fossil fuel.

9.1 Crude oil can contain a mixture of the compounds listed in the table below.

Compounds	Boiling point /°C
Butane	0
Pentane	36
Hexane	69
Heptane	99
Octane	
Nonane	152
Decane	175



9.1.1 What is the name of the homologous series to which these compounds belong?

..... (1)

9.1.2 Predict the boiling point of octane:

..... (1)

9.1.3 Which is the **most** volatile compound listed in the table?

..... (1)

9.1.4 State and explain the trend in the boiling points of these compounds.

.....

 (3)

9.1.5 Compare the boiling points of hexane with 2-methylpentane.

Tick (✓) **one** box

☐ hexane has a higher boiling point than 2-methylpentane.

☐ 2-methylpentane. has a higher boiling point than hexane

☐ 2-methylpentane. and hexane have the same boiling points (1)

9.2 To make crude oil more useful, it is **separated into fractions**.

9.2.1 Use the correct word from the box to complete each sentence.

boiling	synthesis	decomposition	distillation
pure	filtration	impure	molecular

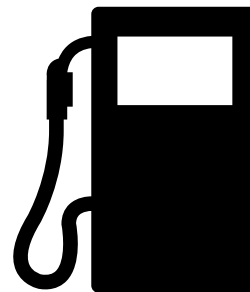
Crude oil is because it contains a mixture of different compounds.

The substances in crude oil have different points.

Crude oil is separated by fractional (3)

Petrol is one of the fractions produced from crude oil.

Car engines use a mixture of petrol and air.



9.2.2 What type of reaction happens to petrol in a car engine?

Tick (✓) **one** box

☐ combustion

☐ decomposition

☐ neutralisation

(1)

Petrol contains **octane**.

9.2.3 Write a balanced chemical equation showing the reaction between octane and oxygen.

.....
 (4)

9.2.4 Explain why octane is a saturated hydrocarbon.

.....

 (2)

9.3 Some fractions from crude oil contain large hydrocarbon molecules.

These molecules can be thermally cracked to produce smaller, more useful molecules. This process requires high temperatures. An equation the cracking of decane is:



9.3.1 During the cracking of **decane**, is the change in enthalpy POSITIVE or NEGATIVE? Explain your answer.

.....

.....

.....

.....

.....

..... (3)

9.3.2 Decane has a melting point of -30°C at 1 atm.

Which option best describes the type of solid that decane becomes below its melting point?

Tick (✓) **one** box

☐ polymer

☐ ionic

☐ network (giant) covalent

☐ molecular

(1)

9.3.3 Why is propane used as a fuel?

Tick (✓) **one** box

☐ propane is a renewable resource

☐ propane is a catalyst

☐ propane releases thermal energy which can be harnessed to do useful work

☐ propane has a high ignition point

(1)

9.3.4 State the functional group found in ethene molecules.

..... (1)

9.3.5 What is the colour change when bromine water reacts with ethene?

Tick (✓) **one** box

☐ red-brown to colourless

☐ red-brown to orange

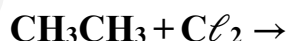
☐ pink to colourless

(1)

9.3.6 Name and draw the structural formulae of two possible positional isomers for product X

(3)

9.4 Consider the following redox reaction involving CH_3CH_3 :



- Complete and balance the equation, using **condensed structural** formulae.
- Give the general and specific organic reaction types.
- Give the name of the oxidising agent.
- Give one reaction condition.

BALANCED chemical equation..... (2)

GENERAL reaction type: (1)

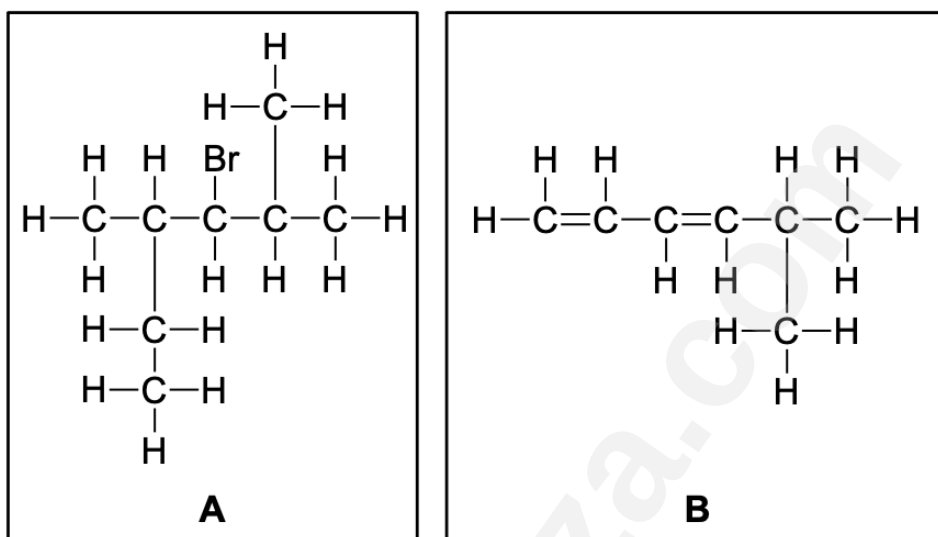
SPECIFIC reaction type: (1)

OXIDISING agent name: (1)

ONE reaction condition: (1)

Question 10 [12 Marks]**IUPAC NAMING**

10.1 Consider the compounds, labelled A and B, below and answer the questions that follow.



10.1.1 Write down the IUPAC name of compound A.

.....
 (4)

10.1.2 Write down the IUPAC name of compound B.

.....
 (4)

10.2 Draw the structural formula of 3-ethyl-2,4-difluoro-5-methyloctan-3-ol.

(4)

ADDITIONAL SPACE:

Important: Please indicate AT THE QUESTION that you've used this additional space.

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ADDITIONAL SPACE:

Important: Please indicate AT THE QUESTION that you've used this additional space.

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