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HeronBridge
COLLEGE

PHYSICAL SCIENCE
EXAMINATION
PAPER 2 - CHEMISTRY

GRADE 12

SEPTEMBER 2018

TIME: 3 hours

MARKS: 200

Examiner: B. Beukes

Moderator: M. Janneker

INSTRUCTIONS

1. This examination consists of:
 - a question paper of 20 pages;
 - an answer sheet of 2 pages; and
 - a data and formulae booklet (pages i – iii).

Please make sure that your question paper is complete.

2. Read the questions carefully.
3. It is in your own interest to write legibly and to set your work out neatly.
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer. Where appropriate, express answers to TWO decimal places.

ACKNOWLEDGMENTS : Various DBE, IGCSE, NSC and Cambridge A level papers, IEB and SQA examinations boards.

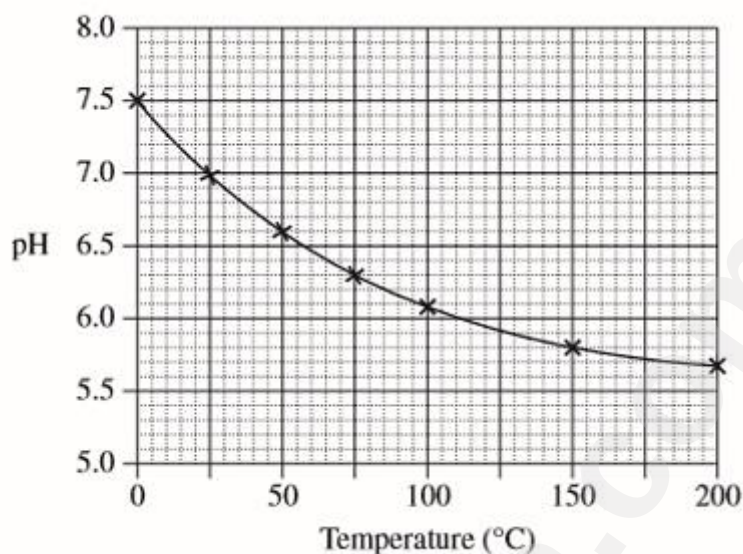
Question 1:**[2×10=20]**

Choose the most correct answer from the options presented. Each question has only ONE correct answer. Mark the answer of your choice with a cross (X) on the ANSWER SHEET that has been provided.

Answer on the answer sheet provided.

- 1.1 Dry ice (solid carbon dioxide), when heated, changes directly from the solid phase to the gas phase. Which type of intermolecular forces would one expect to be present between the carbon dioxide molecules to allow for this to happen?
- A. Covalent forces
 - B. Dipole-dipole forces
 - C. Hydrogen bonding forces
 - D. London forces
- 1.2 If exactly one gram of each of the following compounds is treated with excess hydrochloric acid, which would release the greatest amount of $\text{CO}_2(\text{g})$ at STP?
- A. K_2CO_3
 - B. KHCO_3
 - C. Na_2CO_3
 - D. NaHCO_3

- 1.3 The graph shows the pH of a solution of a weak acid, HA, as a function of temperature.



What happens as the temperature **decreases**?

- A. HA becomes less ionised and the H^+ concentration increases.
- B. HA becomes less ionised and the H^+ concentration decreases.
- C. HA becomes more ionised and the H^+ concentration increases.
- D. HA becomes more ionised and the H^+ concentration decreases.

- 1.4 In which of the following reactions is the metal reduced?

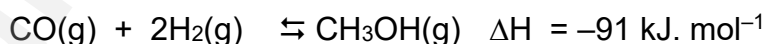
- A. $2FeCl_2(aq) + Cl_2(g) \longrightarrow 2FeCl_3(aq)$
- B. $CuS(s) + O_2(g) \longrightarrow Cu(s) + SO_2(g)$
- C. $2Al(OH)_3(aq) \longrightarrow Al_2O_3(s) + 3H_2O(l)$
- D. $Ca(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2(g)$

- 1.5 A standard electrochemical cell is based on the following hypothetical half-reactions:



Which ONE of the following will be the strongest reducing agent?

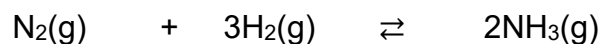
- A. Q
 - B. R
 - C. R^{2+}
 - D. Q^{3-}
- 1.6 Gold is very soluble in mercury. A gold ring exposed to mercury rapidly takes on a shiny silvery appearance as the mercury dissolves in the gold forming an alloy. The mercury may be removed by oxidising the metallic mercury into a soluble ionic form. Use the redox table to establish which of the following reactants will oxidise mercury into a soluble form, without oxidising the gold, thereby restoring the gold appearance of the ring.
- A. H_2O_2
 - B. acidified KCr_2O_7
 - C. acidified $KMnO_4$
 - D. Fe^{3+}
- 1.7 Methanol is synthesised from carbon monoxide and hydrogen according to the equation below.



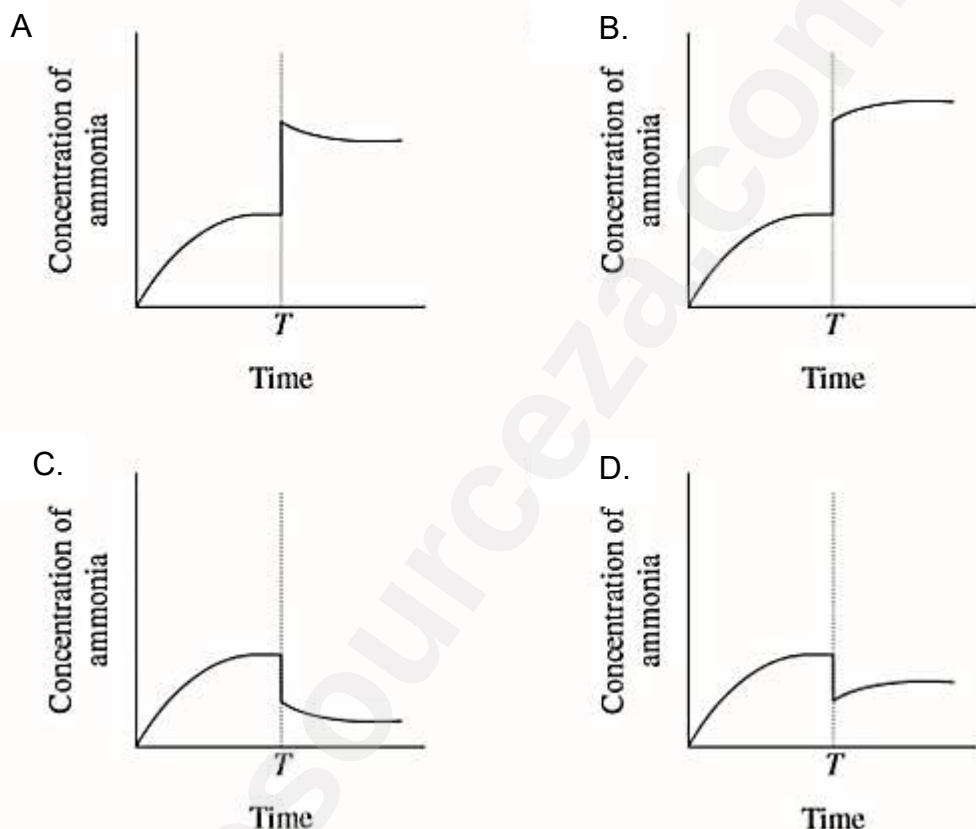
Which one of the following changes would **not** affect the value of the equilibrium constant and would **not** increase the yield of methanol?

- A. increase in temperature
- B. decrease in temperature
- C. increase in pressure
- D. decrease in pressure

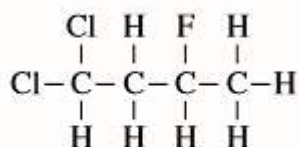
- 1.8 This equation shows an equilibrium established in the synthesis of ammonia from its component gases:



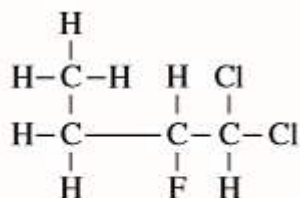
If the volume of the reaction chamber is suddenly halved at time T , which of the following best depicts changes in the concentration of ammonia over time?



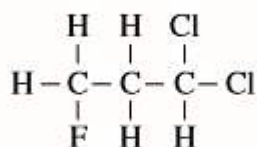
1.9 Four compounds, W, X, Y and Z are represented below:



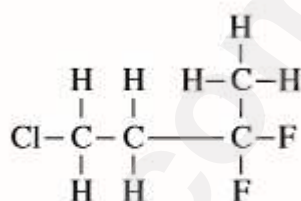
Compound W



Compound X



Compound Y



Compound Z

Which of the following is a pair of isomers?

- A. W and X
- B. W and Y
- C. X and Y
- D. Y and Z

1.10 Which pair of substances correctly matches the reactant and product of an addition reaction?

	Reactant	Product
A.	$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{OH}$	$\text{CH}_3 - \text{CH}_2 - \text{CH} = \text{CH}_2$
B.	$ \begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH} - \text{CH}_3 \\ \\ \text{OH} \end{array} $	$\text{CH}_3 - \text{CH}_2 - \text{CH} = \text{CH} - \text{CH}_3$
C.	$\text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3$	$ \begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{CH} - \text{CH}_2 - \text{CH}_3 \\ \\ \text{Cl} \end{array} $
D.	$ \begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{C} \\ \\ \text{OH} \end{array} $	$ \begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{C} \\ \\ \text{O} - \text{CH}_3 \end{array} $

Question 2:

2.1 The following substances are in the liquid phase:

- A. CH_3Cl
- B. ZnCl_2
- C. CBr_4
- D. Cu
- E. NH_3

Write down ONLY the letter or letters of the substances that correspond to the correct answer.

2.1.1 The liquid that conducts electricity through the movement of ions.

2.1.2 The liquid that exhibits hydrogen bonding.

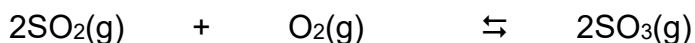
2.1.3 The liquid that exhibits dipole-dipole interactions.

2.1.4 Liquids that should dissolve or be miscible with water.

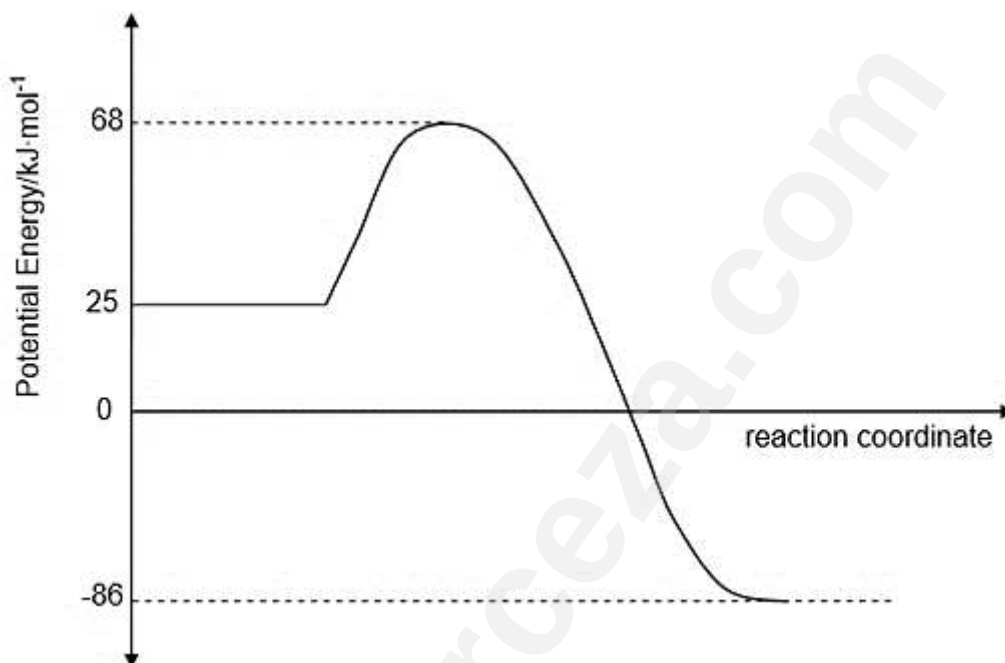
2.1.5 Liquids consisting of non-polar molecules.

2.1.6 A liquid that exhibits metallic bonding. (7)

- 2.2 One of the steps in the preparation of sulphuric acid is represented by the following reversible reaction:



The graph shows the energy change during this reaction:



- 2.2.1 Is the reaction exothermic or endothermic? (1)

- 2.2.2 According to collision theory, give TWO conditions necessary for the reaction to take place. (2)

Vanadium pentoxide is added as a catalyst in the above reaction.

- 2.2.3 Explain how the presence of a catalyst affects the rate of the reaction. (2)

- 2.2.4 Calculate the enthalpy change of this reaction. (3)

At 68 kJ.mol⁻¹ an activated complex is formed.

- 2.2.5 Define the term *activated complex*. (2)

- 2.2.6 Calculate the activation energy for the reverse reaction. (2)

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Question 3:

3.1 The hydrogen phosphate ion (HPO_4^{2-}) can act as an ampholyte.

3.1.1 Define a *weak acid*. (2)

3.1.2 Consider the following reaction:



Is the HPO_4^{2-} ion in this reaction acting as a Bronsted-Lowry acid or base? Give a reason for your answer. (2)

3.1.3 Is the ion PO_4^{3-} an acid or a base? (1)

3.2 A container holds an unknown solution. On the label it is written 0,2 M ($0,2 \text{ mol} \cdot \text{dm}^{-3}$) and $\text{pH} = 13,3$.

3.2.1 Is the solution acidic, basic or neutral? (1)

A student titrates exactly 25 cm^3 of the solution with an unknown concentration of sulphuric acid. At the endpoint it is found that $17,85 \text{ cm}^3$ of sulphuric acid was used. The balanced equation for the reaction is:

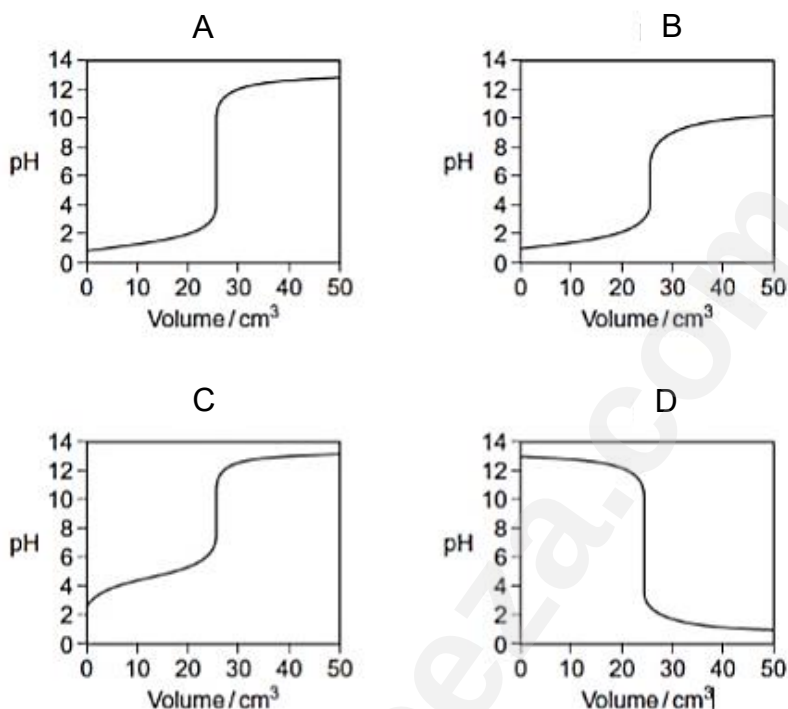


3.2.2 Define an *endpoint (neutralization point)*. (2)

3.2.3 Calculate the concentration of the sulphuric acid solution. (5)

3.2.4 Use a calculation to identify element X if the molar mass of the compound XOH is $56 \text{ g} \cdot \text{mol}^{-1}$. (3)

- 3.3 Titration curves, labelled A, B, C and D, for combinations of different aqueous solutions of acids and bases are shown below. All the solutions have concentrations of $0,1 \text{ mol.dm}^{-3}$.



From the curves A, B, C and D, choose the curve produced by the addition of:

- 3.3.1 sodium hydroxide **to** 25 cm^3 of ethanoic acid
 3.3.2 ammonia **to** 25 cm^3 hydrobromic acid (high K_a value)
 3.3.3 hydrochloric acid **to** 25 cm^3 of potassium hydroxide (3)

The table below shows some information about some indicators:

Indicator	pH range	Lower pH colour	Higher pH colour
pentamethoxy red	1.2–3.2	violet	colourless
naphthyl red	3.7–5.0	red	yellow
4-nitrophenol	5.6–7.0	colourless	yellow
cresol purple	7.6–9.2	yellow	purple

- 3.3.4 Which indicator in the table could be used for the titration that produces curve A but not for the titration that produces curve B? (2)

- 3.3.5 Give the colour change at the end point of the titration that produces curve D when 4-nitrophenol is used as an indicator. (2)

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Question 4:

Hydrochloric acid reacts with solid calcium carbonate in the form of marble chips. The products of the reaction are aqueous calcium chloride, carbon dioxide gas and water.



An investigation is planned to find out how changes in one variable affect the rate of reaction.

- 4.1 The concentration of the hydrochloric acid is one independent variable that could be investigated. Identify TWO other variables that could be investigated. (2)
- 4.2 Explain using collision theory how an increase in concentration will affect the rate of a reaction. (3)
- 4.3 The volume of carbon dioxide produced per unit time is one dependent variable that could be measured to determine the rate of reaction. Identify another dependent variable that you could measure to determine the rate of reaction. (1)

In order to carry out the investigation to determine how the rate of reaction varies with concentration, you are provided with some marble chips and HCl of $2,0 \text{ mol.dm}^{-3}$. In a series of experiments, you are to measure the time taken to collect a volume of 100 cm^3 of CO_2 for several different concentrations of HCl.

- 4.4 State the *independent variable* for this investigation. (1)
- 4.5 State the *dependent variable* for this investigation (1)
- 4.6 One of the concentrations that could be used in this experiment is $0,5 \text{ mol.dm}^{-3}$. Describe in point form how you would accurately dilute the $2,0 \text{ mol.dm}^{-3}$ HCl to obtain $0,5 \text{ mol.dm}^{-3}$ HCl. (5)

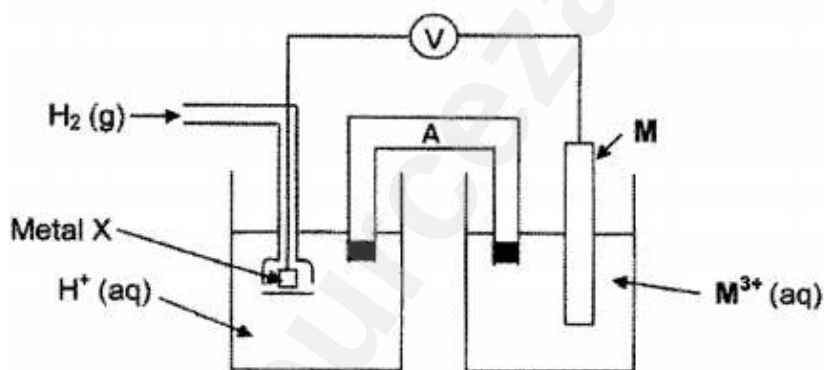
[13]

Question 5:

- 5.1 The standard cell potential produced by a galvanic cell consisting of a cobalt electrode in contact with a solution of $\text{Co}^{2+}(\text{aq})$ and a silver electrode in contact with a solution of $\text{Ag}^+(\text{aq})$, is 1,08 V.

- 5.1.1 Define a *reduction*. (2)
- 5.1.2 Write down the reduction half-reaction for the above cell. (2)
- 5.1.3 Identify the oxidizing agent. (1)
- 5.1.4 Write down the cell notation of this cell. (4)

- 5.2 An unknown metal, M, is connected to a hydrogen standard half-cell as indicated below. The metal, M, is placed in a solution of its salt, $\text{M}^{3+}(\text{aq})$.



- 5.2.1 What is the purpose of the standard half-cell? (2)
- 5.2.2 Name the metal labelled X in the hydrogen half-cell. (1)
- 5.2.3 State two functions of the component labelled A. (2)
- 5.2.4 The reading on the voltmeter is 0,74 V. Identify the unknown metal, M. (2)
- 5.2.5 Write down the overall ionic cell reaction for the above galvanic cell. (2)
- 5.2.6 Provide the complete cell notation for the cell above. (3)

5.2.7

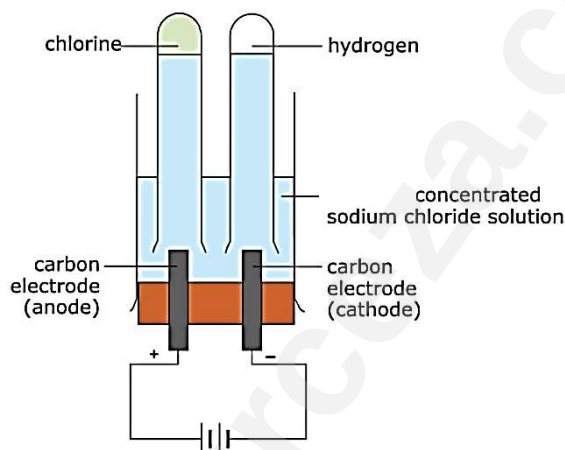
How will the reading on the voltmeter change with an increase in the concentration of the M^{3+} ion? Write only INCREASE, DECREASE or HAVE NO EFFECT. Give a reason for your Answer.

(3)

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Question 6:

- 6.1 Sodium chloride can be easily dissolved in water. The diagram below shows the apparatus used to electrolyse aqueous sodium chloride (brine). Two gases, hydrogen and chlorine, are formed as products.

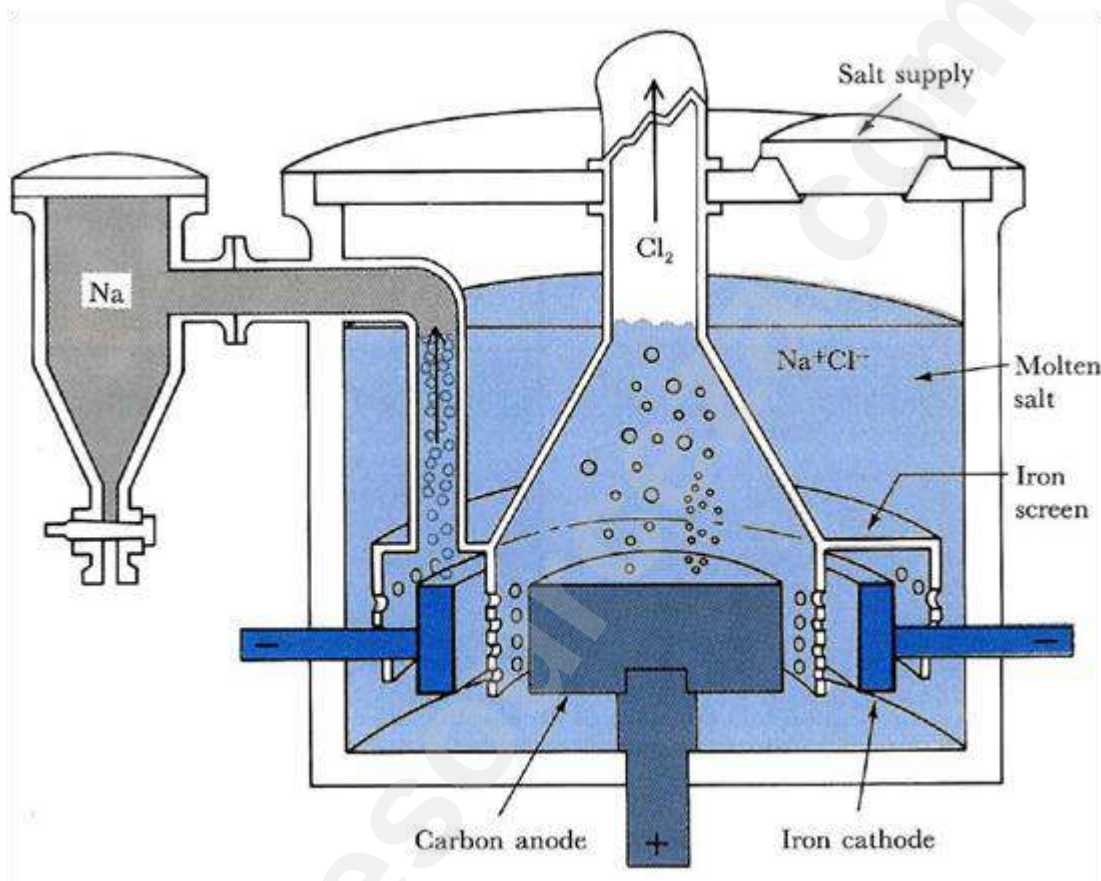


- 6.1.1 Write down the half-reaction that takes place at the positive electrode. (2)
- 6.1.2 Give one reason why carbon is used for the electrodes? (1)
- 6.1.3 Explain why a brine solution is a suitable electrolyte. Make reference to the type of bonding that takes place in brine. (2)
- 6.1.4 Use the relative strengths of the oxidising agents present to explain why sodium metal is NOT produced at the cathode in the cell above. (2)
- 6.2 A **constant** current of 4 000 A is passed through a chlor-alkali cell for 2,5 minutes.
- 6.2.1 Calculate the volume of chlorine gas produced, at STP, at the anode during this period of time. (8)

6.2.2 The purity of the sodium hydroxide produced in the chlor-alkali industry depends on the extent to which it is separated from the chlorine gas produced by the membrane cell. Briefly describe how chlorine gas and sodium hydroxide are prevented from mixing in the membrane cell.

(2)

6.3 The diagram below shows the apparatus used to electrolyse molten NaCl .



The effect of current on the mass of sodium produced was measured. The current was passed through the brine for 10 minutes each time. The results are tabulated below.

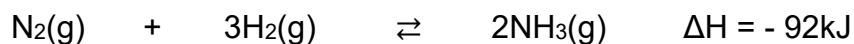
Current	Mass of Na
1,0 A	0,14 g
4,0 A	0,57 g
6,8 A	1,00 g
12,0 A	1,72 g
13,6 A	1,94 g

- 6.3.1 Explain why it is not economical to use molten NaCl. (2)
- 6.3.2 State one error in the format of the table. (1)
- 6.3.3 Plot a graph of the data on the graph paper provided ensuring that the correct variables appear on each axis. (7)
- 6.3.4 Use your graph to predict the mass of sodium that would be produced if a current of 2,5 A was used. (2)
- 6.3.5 What is the relationship between the current and the mass of sodium deposited, as shown by your graph? (2)

[31]

Question 7:

7.1 The Haber process is represented by the following equation:



In a small scale plant, x moles of $\text{N}_2(\text{g})$ and 8 moles of $\text{H}_2(\text{g})$ are added in a 5 dm^3 sealed container. When equilibrium is reached at temperature T_1 , it is found that 25,5 g of NH_3 is present.

7.1.1 State *Le Chatelier's principle*. (2)

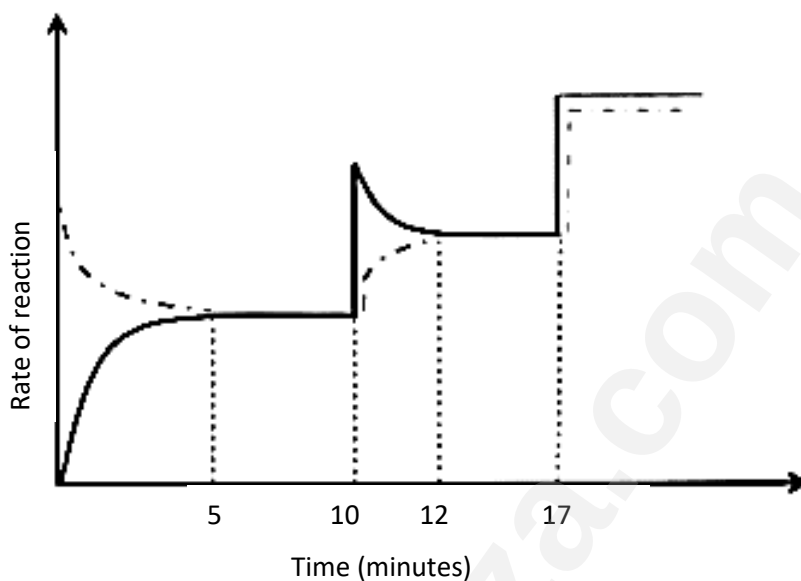
7.1.2 Write the mass action expression for this reaction. (2)

7.1.3 If the K_c for this reaction is 0,13 calculate the initial number of moles of $\text{N}_2(\text{g})$. (7)

7.1.4 How will the equilibrium concentration of the products compare with the reactants? Simply write LARGER THAN, SMALLER THAN or EQUAL TO. (1)

7.1.5 A new equilibrium is now established at a higher temperature T_2 . Will the equilibrium constant INCREASE, DECREASE or STAY THE SAME? Use Le Chatelier's principle to explain the answer. (4)

- 7.2 Only NH_3 is added to a second sealed container and allowed to reach equilibrium at 200°C . The rate of the forward and reverse reactions is plotted on the graph below:



- 7.2.1 Which reaction (FORWARD or REVERSE) is represented by the solid line in the graph? Explain fully. (2)
- 7.2.2 When did the system reach equilibrium for the first time? (1)
- 7.2.3 What change (PRESSURE or TEMPERATURE) was made at 10 minutes? Explain fully. (3)
- 7.2.4 What change was made at 17 minutes? Explain fully. (3)

[25]

Question 8:

8.1 The letters A to F in the table below represent six organic compounds.

A	$\text{CH}_3\text{CHCHCH}_3$	B	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
C	$\text{CH}_3\text{CH}_2\text{F}$	D	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
E	$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3\text{CH}_2-\text{O}-\text{C}-\text{CH}_2\text{CH}_3 \end{array}$	F	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$

8.1.1 Define a *homologous series*. (2)

8.1.2 Write down the letter(s) that represent(s) each of the following:
(A compound may be used more than once.)

a) An unsaturated hydrocarbon. (1)

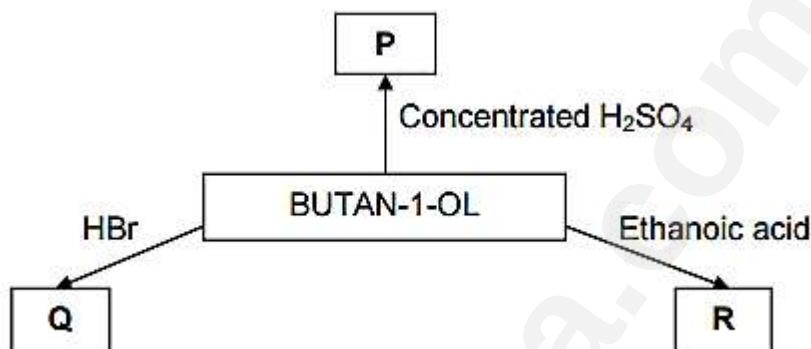
b) Two compounds which are **chain** isomers of one another. (1)

8.1.3 Give the IUPAC name of compound D. (2)

8.1.4 The molar mass of compounds D and F are very similar. The boiling point of compound D is 28 °C, yet compound F has a boiling point of 117 °C. With reference to the relevant intermolecular forces explain why their boiling points are so different. (4)

- 8.2 **Butanol** is used as an ingredient in perfumes and as a solvent for the extraction of essential oils. **Butanol** is also used as an extractant in the manufacture of antibiotics, hormones, and vitamins; a solvent for paints, coatings, natural resins, gums, synthetic resins, dyes, alkaloids, and camphor. Some of the reactions of BUTAN-1-OL are represented in the flow diagram below.

P, Q and R represent the organic products formed.



Product P is formed when butan-1-ol is heated in the presence of concentrated sulphuric acid.

- 8.2.1 Name the type of reaction that takes place. (1)
- 8.2.2 Write a balanced equation for the reaction that takes place using structural formulae for the reactants and products. (3)
- 8.2.3 Write down the IUPAC name of a **functional** isomer of ethyl hexanoate. (2)

Product R is formed when butan-1-ol reacts with ethanoic acid in the presence of an acid catalyst.

- 8.2.4 Name the type of reaction that takes place. (1)
- 8.2.5 Give the name and structural formula of the organic product, R, formed. (3)
- 8.2.6 Write down the IUPAC name of a positional isomer of compound R. (2)

When HBr reacts with butan-1-ol, compound Q, a haloalkane, is formed.

- 8.2.7 Name the type of reaction that takes place. (1)
- 8.2.8 Give the IUPAC name of the haloalkane, Q, that formed, and any other product formed. (3)

[26]

Question 9:

Viscosity is a measure of a fluid's **resistance** to flow. A student compares the viscosities of three alcohols by measuring the time it takes 25 ml of each of the alcohols to flow from a pipette. This time is an indication of the viscosity of each alcohol.

The results are in the table below.

Alcohol	Flow Time (s)
Methanol	4,0
Ethanol	7,5
Propan-1-ol	14,2

- 9.1 Write a hypothesis for the student's investigation. (2)
- 9.2 Which alcohol in the table has the highest viscosity? Explain your answer by referring to the results of the student's experiment. (2)
- 9.3 Name the functional group in alcohols. (1)
- 9.4 Explain the trend of viscosities in the table by referring to the intermolecular forces of the three alcohols. (3)
- 9.5 The student now wants to compare the viscosities of two alcohols with the same molecular mass: 2-methylpropan-2-ol and butan-2-ol. These two compounds are isomers.
- 9.5.1 Draw the **structural formulae** for 2-methylpropan-2-ol and butan-2-ol. Clearly label each structure. (4)
- 9.5.2 Define an *isomer*. (2)
- 9.5.3 What **type** of structural isomers are 2-methylpropan-2-ol and butan-2-ol? (1)
- 9.5.4 Which one of these two alcohols would have the higher viscosity? Explain your answer. (4)

[19]