

QUESTION 1 MULTIPLE CHOICE

Every question has only one correct answer. You may use the space provided to solve the questions, BUT YOU MUST INDICATE YOUR CHOSEN ANSWER FOR EACH QUESTION IN THE GRID BELOW. Make a clear 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 Which one of the following contains 1 mol of **atoms**?

- A 16 g of SO_2
- B 28 g of N_2
- C 14 g of C_2H_4
- D 20 g of SO_3

1.2 Consider the balanced equation below:

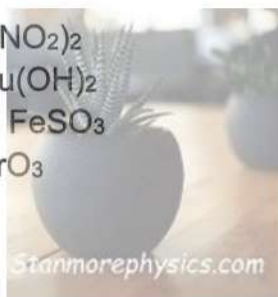


0,4 mol of NH_3 is mixed with 0,8 mol of O_2 in a closed container. The reaction goes to completion. What is the total amount of gas in the container at the end of the reaction?

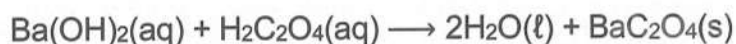
- A 1,3 mol
B 10,0 mol
C 1,0 mol
D 0,4 mol

1.3 In which one of the following pairs of salts do the cations both have the same charge?

- A PbS_2 and $\text{Co}(\text{NO}_2)_2$
B CdSO_4 and $\text{Cu}(\text{OH})_2$
C $\text{Ag}_2\text{Cr}_2\text{O}_7$ and FeSO_3
D AuPO_4 and CrO_3



1.4 Which of the given reaction types describe the reaction below?



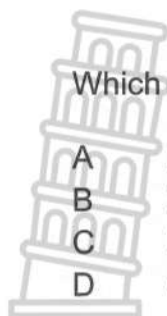
- 1 Redox
2 Precipitation
3 Neutralisation

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

1.5 The following system is at equilibrium in a sealed gas flask:



Which one of the following changes will **increase** the amount of $Y_2(g)$ in the flask?



- A Decrease the volume of the flask
- B Remove $X_2(g)$ from the flask
- C Remove $X_3Y(g)$ from the flask
- D Cool the flask

1.6 The auto-ionisation of water is endothermic. Which one of the following is TRUE when water is heated to just below its boiling point?

- A $[H_3O^+][OH^-] < 1 \times 10^{-14}$
- B $[H_3O^+] = 1 \times 10^{-7} \text{ mol}\cdot\text{dm}^{-3}$
- C The pH of the solution is less than 7.
- D $[H_3O^+] > [OH^-]$



1.7 Consider the reaction equation:



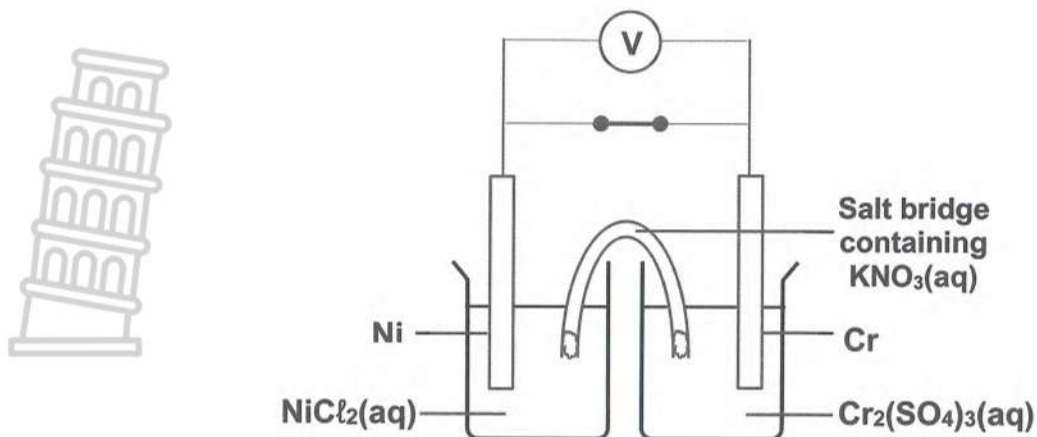
Which of the following are conjugate acid-base pairs in this reaction?

- 1 $NaOH$ and Na^+
- 2 OH^- and H_2O
- 3 CH_3COOH and $NaOH$
- 4 CH_3COOH and CH_3COO^-

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

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1.8 Consider the galvanic cell depicted below:



Which of the following ions will move into the salt bridge when the cell is operating?

- A Ni^{2+} , Cl^-
- B Cr^{3+} , SO_4^{2-}
- C Cr^{3+} , Cl^-
- D Ni^{2+} , SO_4^{2-}

1.9 A mixture of hydrocarbons is separated by distillation. Which one of the following options is correct for this process?

	Type of process	Bonds/forces broken/overcome
A	Physical	London forces
B	Chemical	London forces
C	Physical	Covalent bonds
D	Chemical	Covalent bonds

1.10 Which one of the following compounds is a chain isomer of butanoic acid?

- A Pentanoic acid
- B Ethyl ethanoate
- C 2-methylbutanoic acid
- D Methylpropanoic acid

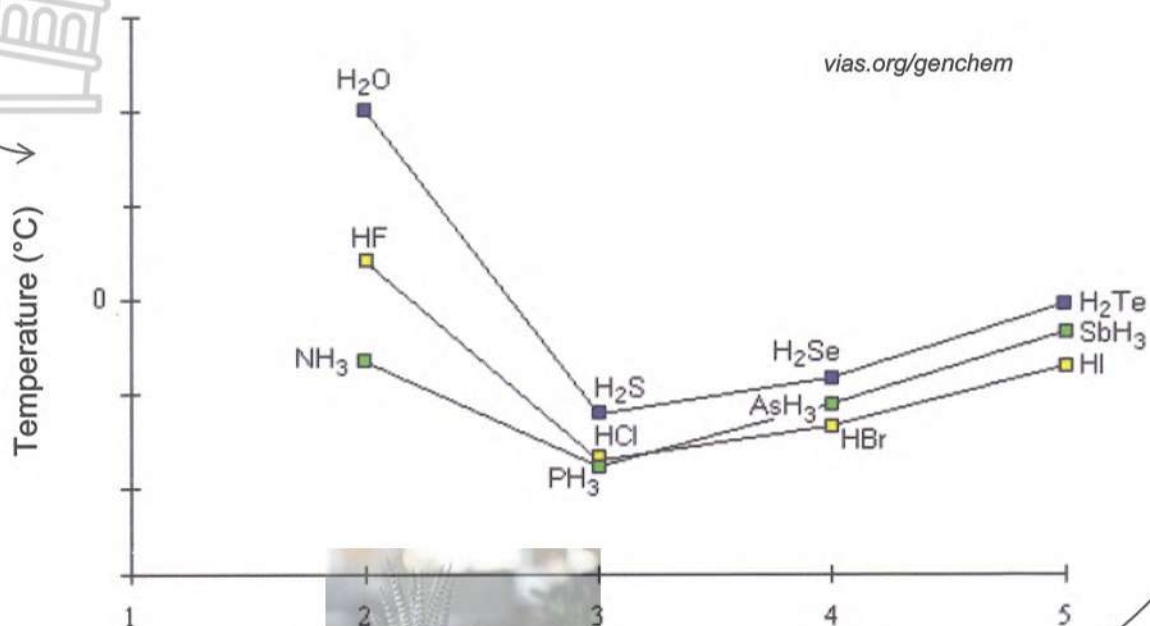
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QUESTION 2

The graph below shows the boiling points of the hydrides of Groups V, VI, and VII at a pressure of 1 atmosphere.

2.1 Supply all the temperature values on the y-axis. (2)

2.2 Supply the appropriate x-axis label in the space provided. (1)



2.3 Identify one compound shown on the graph that has non-polar covalent bonds. Explain why the bonds are non-polar. (2)

2.4 Name the bonds/forces responsible for the unusually high boiling points of H₂O, HF, and NH₃. (1)

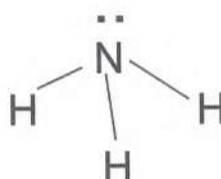
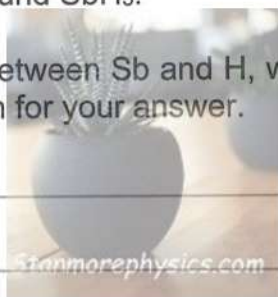
2.5 H₂O has the highest boiling point. Give a reason why the intermolecular forces are stronger in H₂O than in NH₃ or HF. (1)

2.6 HF has a higher boiling point than NH₃. Explain one reason that the intermolecular forces are stronger in HF than in NH₃. (2)

2.7 For NH_3 :

2.7.1 Give the common name of this compound. (1)

2.7.2 Add to the diagram below to show, by means of a dotted line, the intermolecular force(s) in this compound. (2)

2.8 Consider the compound SbH_3 .2.8.1 In the bond between Sb and H, which atom would be assigned the δ^+ label? Give a reason for your answer. (2)2.8.2 SbH_3 has a higher boiling point than NH_3 . Refer to ALL the intermolecular forces present to explain why more energy is needed to separate SbH_3 molecules than NH_3 molecules. (4)

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QUESTION 3

- 3.1 Sodium nitrate undergoes thermal decomposition to form sodium oxide, nitrogen dioxide, and oxygen.

3.1.1 Write a balanced equation for the reaction. (3)



3.1.2 During the reaction, more energy is absorbed than released. Circle the correct option in the table.

The reaction is

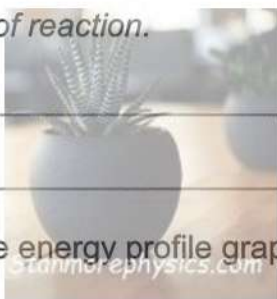
EXOTHERMIC

ENDOTHERMIC

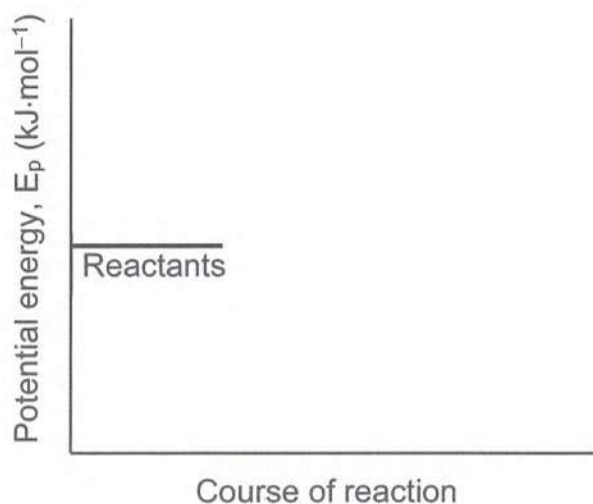
(1)

3.1.3 Define the *activated complex*. (2)

3.1.4 Define *heat of reaction*. (2)



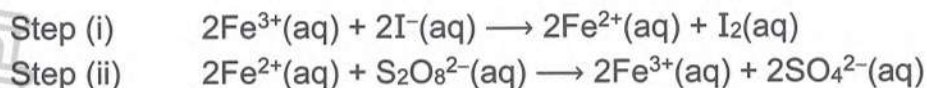
3.1.5 Complete the energy profile graph for this reaction. (1)



3.1.6 On the graph, label E_a , the activation energy, and ΔH , the heat of reaction. (2)

3.1.7 On the y-axis, mark the potential energy of the activated complex with a **P**. (1)

- 3.2 Study the following two-step redox reaction of the peroxydisulfate ion ($\text{S}_2\text{O}_8^{2-}$) with the iodide ion in aqueous solution:



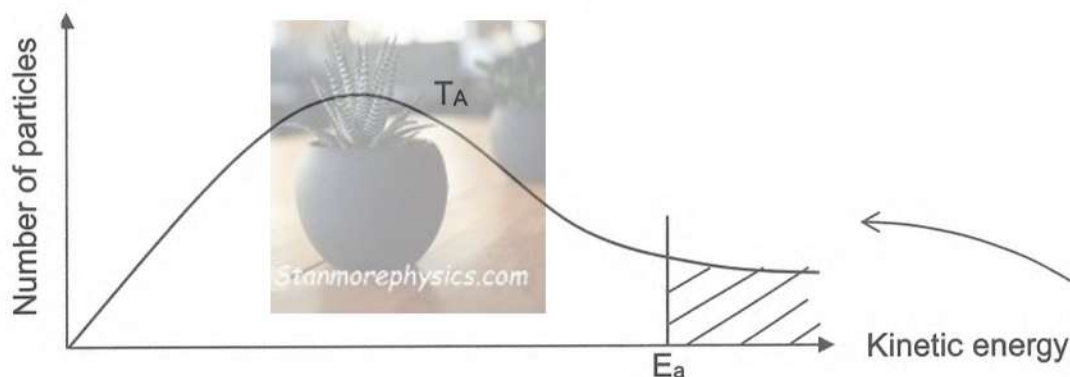
Overall: _____

- 3.2.1 Complete the definition: A *redox reaction* is a reaction involving... (1)

- 3.2.2 In the space provided above, write down the overall (net) reaction that takes place. State symbols are not required. (2)

- 3.2.3 Identify the catalyst in this reaction. (1)

- 3.3 Consider the curve shown below for a reaction mixture at temperature T_A :



- 3.3.1 Supply the name for this type of curve. (2)

- 3.3.2 On the above diagram, redraw the curve for the mixture at a **lower** temperature, T_B . (2)

- 3.3.3 On the above diagram, show and label the effect of adding a catalyst. (1)

- 3.3.4 Alistair says that adding a catalyst will result in more collisions between reactant particles. Circle the answer in the table and explain. (3)

Alistair is

☐ CORRECT

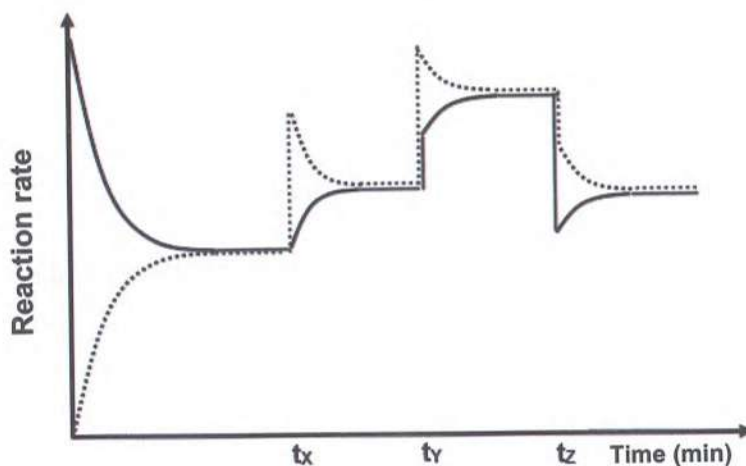
☐ INCORRECT

because _____

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QUESTION 4

- 4.1 Solid A and gas B were placed in a sealed 1,0 dm³ container and allowed to react. Dynamic chemical equilibrium was reached at a certain temperature. The equation for the reaction is as follows:



- 4.1.1 Explain what is meant by *dynamic chemical equilibrium*. (3)



- 4.1.2 When equilibrium was initially established, the value of K_c was 0,020. There were 0,2 mol A and 0,1 mol AB₃ in the 1,0 dm³ container. Calculate the molar concentration of B in the container. (4)

- 4.1.3 Changes are made to the system at times t_x and t_y . Describe the changes (to either the temperature, the pressure, or the concentration) at...

t_x _____ (2)

t_y _____ (2)

4.1.4 At time t_z , the volume of the container was changed at constant temperature.



- (a) Circle the correct option in the table: (1)

The volume of the container was

INCREASED

DECREASED

- (b) Explain the change observed on the graph at time t_z ...

- (i) in terms of the collision theory. (4)

- (ii) in terms of Le Châtelier's Principle. (3)



4.2 The equilibrium reaction of $\text{H}_2(\text{g})$ and $\text{Br}_2(\text{g})$ is represented by the following equation:



4.2.1 Write the expression for the equilibrium constant for this reaction. (2)

4.2.2 0,28 mol of H_2 and 0,28 mol of Br_2 are placed into a $3,00 \text{ dm}^3$ container. Equilibrium is established at $2\,600 \text{ K}$. Calculate the equilibrium concentrations of all the reactants and products in the container. (6)



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QUESTION 5

Kyu was tasked to identify an unknown Group 1 metal carbonate salt, represented by the formula M_2CO_3 .

5.1 Define a salt.

(2)



5.2 Write the equation for the complete dissociation of M_2CO_3 in water.

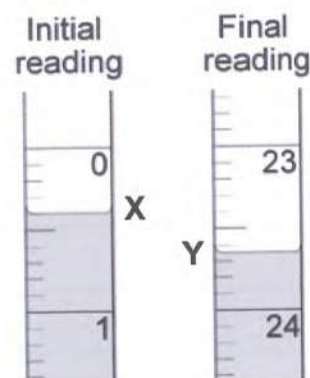
(2)

5.3 Write the equation for the hydrolysis reaction that occurs once M_2CO_3 has dissociated.

(2)

Kyu used a 1,31 g sample of M_2CO_3 to prepare an aqueous solution of volume $200,0 \text{ cm}^3$. $25,00 \text{ cm}^3$ of this solution was titrated with HCl solution of concentration $0,102 \text{ mol}\cdot\text{dm}^{-3}$. The following data was obtained:

	Volume of $0,102 \text{ mol}\cdot\text{dm}^{-3} HCl$ (cm^3)		
Titration	1	2	3
Initial burette reading	24,20	0,20	X:
Final burette reading	47,40	23,50	Y:
Volume added	23,20	23,30	
Average volume for the titration			

Titration 3

The diagram alongside shows the initial and final burette readings for Titration 3.

5.4 Write down the values for **X** and **Y** in the table and then complete the table.

(4)

5.5 Define a *standard solution*.

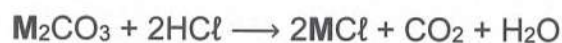
(1)

5.6 Circle the most appropriate indicator that can be used for this titration in the table below:

(2)

Indicator	Methyl orange	Phenol red	Thymol blue
pH range	3,1 – 4,4	6,4 – 8,0	8,0 – 9,6

The equation for the reaction between the metal carbonate and hydrochloric acid is as follows.



- 5.7 Prove by calculation that the concentration of the metal carbonate solution is $0,0474 \text{ mol}\cdot\text{dm}^{-3}$. (3)



- 5.8 Hence, prove by calculation that the molar mass of M_2CO_3 is $138 \text{ g}\cdot\text{mol}^{-1}$. (3)



- 5.9 Identify metal **M** with the aid of a calculation. (2)

[21]

QUESTION 6

Chlorine gas is bubbled through an aqueous solution of potassium bromide.

6.1 Write the balanced net ionic equation for the redox reaction that occurs. (3)

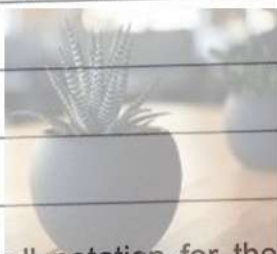


6.2 Identify the oxidising agent in the reaction. (1)

6.3 A galvanic cell can be set up making use of the reaction in Question 6.1.

6.3.1 What is a *galvanic cell*? (3)

6.3.2 Write the cell notation for the cell. Assume that both products of the cell reaction are in aqueous solution. Conditions and state symbols are not required. (4)



6.3.3 Calculate the emf of the cell at standard conditions. (4)

6.3.4 State one method of increasing the emf of this cell, calculated in Question 6.3.3. (1)

6.4 Some bromine is added to an aqueous solution of potassium chloride.

6.4.1 Will a spontaneous reaction take place?

(1)

Circle the correct answer:

YES

NO

6.4.2 Explain the answer by referring to the relative strengths of the oxidising agents. (3)



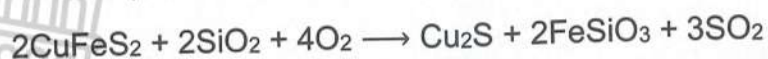
[20]



QUESTION 7

Copper can be extracted from chalcopyrite ore, which is mainly composed of CuFeS_2 .

The reaction equations are given below:



Reaction (i)



Reaction (ii)

- 7.1 When a 3 kg sample of the ore is reacted completely, 1 kg of pure copper is produced. Assume both reactions go to completion. Calculate the percentage of CuFeS_2 in the ore. (6)

CuFeS₂ in the ore.



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- 7.2 Give the name of Cu_2S . (2)

- 7.3 Consider the chemical bonding in the substances involved in reactions (i) and (ii).
Select ONE substance that...

- 7.3.1 has a giant atomic lattice structure. (1)

- 7.3.2 consists of simple molecules in which electrons are unequally shared between atoms. (1)

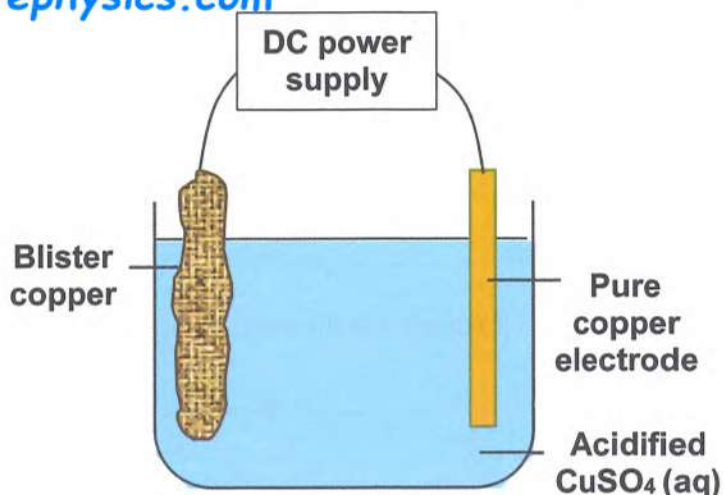
- 7.3.3 conducts electricity when molten but not when solid. (1)

- 7.3.4 would have only London intermolecular forces. (1)

'Blister' copper is about 98% pure and contains trace amounts of **gold** and **cobalt**.

It is purified electrochemically until it is 99,99% pure, which makes it suitable for use as electrical wiring.

The diagram shows a cell used for this purpose.



7.4 Give the correct term for the process of electrochemical purification of a metal. (1)

7.5 Why does the copper used for electrical wiring need to be very pure? (1)

7.6 Which electrode should be connected to the NEGATIVE terminal of the power supply?

Circle the answer:

PURE COPPER	BLISTER COPPER
-------------	----------------

(1)

7.7 Explain why Co²⁺ ions will be found in the CuSO₄ electrolyte but not Au³⁺ ions. (3)

7.8 Explain why the Co²⁺ ions in the solution do not deposit on the electrode. (2)

- 7.9 Consider how the electrode reactions affect the electrolyte concentration during the process.

7.9.1 Circle the correct option in the table. The $[Cu^{2+}]$ in the electrolyte will...

INCREASE	DECREASE	REMAIN THE SAME
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(1)

7.9.2 Explain the answer in Question 7.9.1.

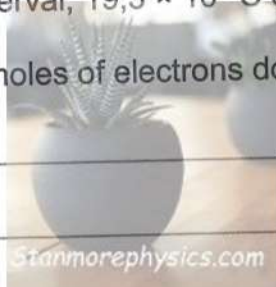
(3)



- 7.10 In a certain time interval, $19,3 \times 10^3$ C of charge passes through the cell.

7.10.1 How many moles of electrons does this represent?

(3)



7.10.2 Hence, calculate the mass of copper that will be deposited on the pure copper electrode during this time interval.

(3)

[30]

QUESTION 8

8.1 The compounds 1,1-dibromobutane and 1,2-dibromobutane are structural isomers. (2)

8.1.1 Define *structural isomers*.



8.1.2 What type of structural isomers do these two compounds represent? (1)

8.2 Name the **homologous series**...

8.2.1 of the organic compound formed when an alcohol reacts with a carboxylic acid. (1)

8.2.2 consisting of saturated hydrocarbons. (1)

8.2.3 of the organic product of a hydrolysis reaction. (1)

8.3 Write down the term for each of the following:

8.3.1 The GENERAL type of organic reaction when alkanes react with halogens (1)

8.3.2 The GENERAL type of organic reaction that results in an unsaturated product (1)

8.3.3 The process of heating a flask containing an organic reaction mixture with a condenser attached to avoid volatile compounds escaping (1)

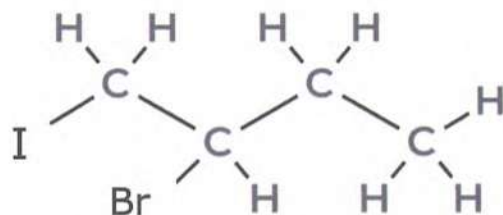
8.4 Give the **chemical formula** of...

8.4.1 the two products of the complete combustion of hydrocarbons. (1)

8.4.2 the reagent used in the standard laboratory test for unsaturation. (1)

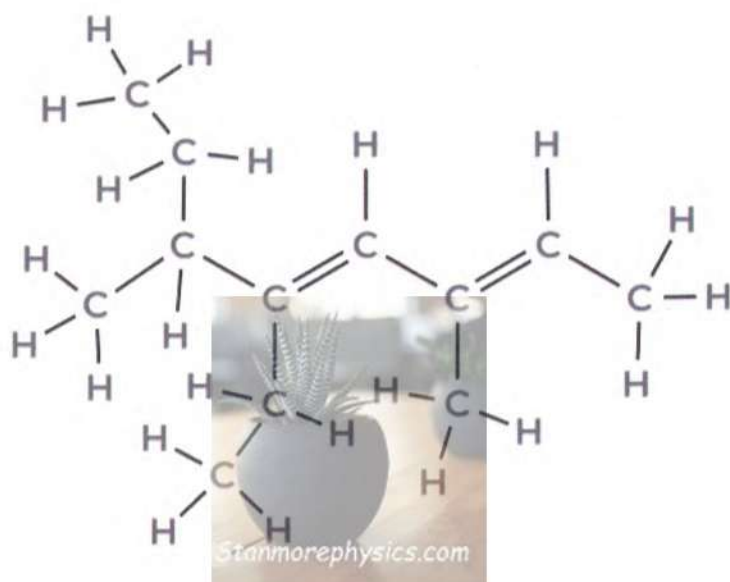
8.5 Give the IUPAC names of the compounds below:

8.5.1



(3)

8.5.2



(4)

8.6 Consider the compound below:



8.6.1 Give the IUPAC name of the compound.

(2)

8.6.2 Draw the **structural** formula of a FUNCTIONAL isomer of the compound.

(2)

8.6.3 CIRCLE and NAME the functional group of the isomer drawn above.

(2)

NAME of functional group:

8.6.4 Circle the correct answer:

(1)

The isomer in Question

8.6.1	8.6.2
-------	-------

 will have a higher boiling point.

8.6.5 Explain why more energy is needed to overcome the intermolecular forces of the isomer chosen in Question 8.6.4. Refer to all the intermolecular forces present and their relative strengths.

(4)

- 8.7 The boiling points of the compounds CH_3F and C_2H_6 at standard atmospheric pressure are compared.

8.7.1 Circle the correct answer:

(1)

CH_3F

C_2H_6

is likely to have a higher boiling point.

8.7.2 Other than atmospheric pressure, write down one controlled variable for this comparison.

(1)

- 8.8 Write balanced equations for the following reactions.

8.8.1 The dehydration of hexan-1-ol. Use **condensed structural** formulae. (5)



8.8.2 The cracking of a 14-C alkane to form a mixture of pentane and propene. Use **molecular** formulae. (4)

[40]

Total: 200 marks

ADDITIONAL SPACE (ALL QUESTIONS)

**REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE
ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.**

