

Examiner: K van Schoor Moderator: external Student name:		Form: 5 Date: 23 Sept 2025 Subject: Physical Sciences Assessment: Preliminary Examination: P2 Chemistry Marks: 200 Time: 3 hr
OR: Exam number: 2 5 1 1 2 8 0 2 _____		

Q	TOTAL	MARK	MODERATED MARK	Q	TOTAL	MARK	MODERATED MARK
1	20			6	19		
2	16			7	17		
3	16			8	22		
4	22			9	33		
5	35						
TOTAL					200		

Please read the following instructions carefully:

1. This question paper consists of 28 pages and a separate Data Sheet.
2. Use the data and formulae whenever necessary.
3. Read the questions carefully.
4. Answer all the questions on the question paper.
5. Show your working in all calculations, including equations used.
6. Non-programmable calculators may be used.
7. Units need not be included in the working of calculations, but appropriate units must be shown in the final answer.
8. Answers must be expressed in decimal format, not left as proper fractions.
9. Where appropriate, express final answers correct to TWO decimal places.
10. It is in your own interest to write legibly and present your work neatly.
11. Graphs and diagrams should be drawn with a sharp dark pencil.
12. If you run out of space for a question, use the additional pages provided.
Clearly indicate the number of your answer should you use this extra space.

The use of CIE and other IEB Schools questions in part, is acknowledged.

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.

e.g. Here the answer C has been marked.

A	B	~~C~~	D
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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 options below correctly gives the formula for iron(III) sulfide?

- A Fe_3S_2
- B Fe_2S_3
- C $\text{Fe}_2(\text{SO}_3)_3$
- D $\text{Fe}_3(\text{SO}_3)_2$

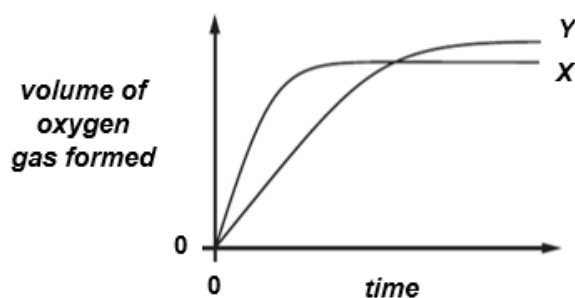
1.2 Which quantity does **not** represent 2 mol of the particles making up the substance?

- A 28 g nitrogen (g)
- B 44,8 dm³ water (g) at STP
- C 80 g calcium (s)
- D 36 g water (ℓ)

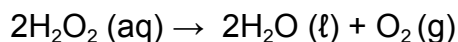
1.3 Which one of the statements below about potassium chloride is correct?

- A It has a high melting point due to its giant structure with strong covalent bonds.
- B It conducts electricity when solid due to its delocalised electrons.
- C It conducts electricity when molten due to mobile ions.
- D It is insoluble in water due to the strong dipole-dipole intermolecular forces.

1.4 In the diagram below, curve X was obtained by measuring the volume of oxygen produced during the decomposition of 100 cm³ of a 1,0 mol · dm⁻³ hydrogen peroxide solution. A catalyst was used.



The equation for the decomposition is given below.

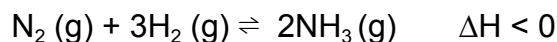


Which alteration to the original experimental conditions would produce curve Y?

- A Adding more of the catalyst.
- B Adding water.
- C Increasing the temperature slightly.
- D Adding an extra 100 cm³ of 0,1 mol · dm⁻³ hydrogen peroxide.

Space for rough work

1.5 Industrially, ammonia is made by the Haber process. The equation is shown.



The conditions used are 450 °C and 200 atm.

Which statements about the conditions are correct?

1. Temperatures below 450 °C give a higher yield of ammonia.
2. Temperatures below 450 °C give a lower yield of ammonia.
3. Pressures above 200 atm give a higher yield of ammonia.
4. Pressure changes do not affect the yield of ammonia.

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

1.6 In which reaction is water acting as a Brønsted-Lowry acid?

- A $\text{H}_2\text{O} + \text{HCl} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^-$
B $\text{H}_2\text{O} + \text{SO}_3 \rightarrow \text{H}_2\text{SO}_4$
C $\text{H}_2\text{O} + \text{Na} \rightarrow \text{H}_2 + \text{NaOH}$
D $\text{H}_2\text{O} + \text{NH}_3 \rightarrow \text{NH}_4^+ + \text{OH}^-$

1.7 Which one of the reactions of HCl, given below, is a redox reaction?

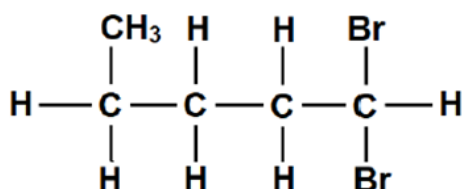
- A $2\text{HCl}(\text{aq}) + \text{K}_2\text{CO}_3(\text{s}) \rightarrow \text{CO}_2(\text{g}) + 2\text{KCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
B $2\text{HCl}(\text{aq}) + \text{MgO}(\text{s}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$
C $2\text{HCl}(\text{aq}) + \text{Na}_2\text{S}(\text{s}) \rightarrow \text{H}_2\text{S}(\text{g}) + 2\text{NaCl}(\text{aq})$
D $2\text{HCl}(\text{aq}) + \text{Fe}(\text{s}) \rightarrow \text{H}_2(\text{g}) + \text{FeCl}_2(\text{aq})$

Space for rough work

1.8 Which of the following metals would most readily react with a solution of iron(III) nitrate to form iron(II) nitrate?

- A cobalt
- B tin
- C copper
- D gold

1.9 The correct IUPAC name for the compound given is ...



- A 1,1-dibromopentane
- B 1,1-dibromo-4-methylbutane
- C 1-methyl-4,4-dibromobutane
- D 1-bromo-1-methylbutane

1.10 The compound $\text{C}_4\text{H}_9\text{Br}$ is treated with hot concentrated KOH in an ethanol solvent. Which organic product/s will form?

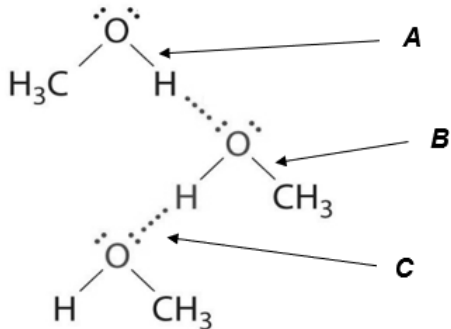
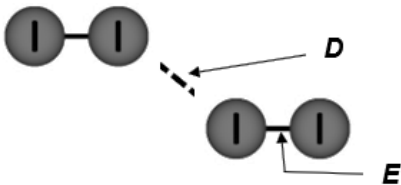
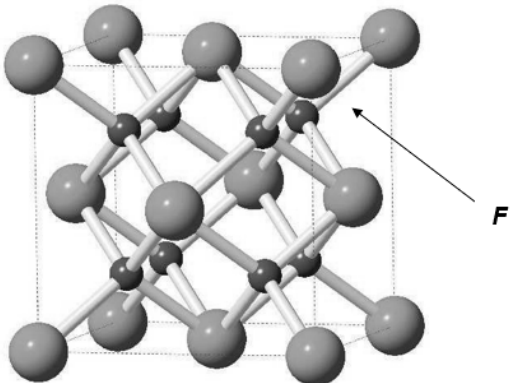
- A $\text{C}_3\text{H}_7\text{COOH}$
- B C_2H_4 and C_2H_5
- C C_4H_8
- D $\text{C}_4\text{H}_9\text{OH}$

Space for rough work

QUESTION 2

[16 marks]

The table below shows a range of chemical compounds and their structures.
The labels **A** to **F** refer to either an intermolecular force or a chemical bond.

Name	Structure
methanol	
iodine	
calcium fluoride	

2.1.1 Define *electronegativity*.

(2)

2.1.2 State the main difference between an *intermolecular force* and a chemical *bond*. (2)

2.1.3 Choose from the letters **A** to **F** to answer the following: (4)

- a) The most polar covalent bond. _____
- b) A hydrogen bond intermolecular force. _____
- c) A pure covalent bond. _____
- d) An ionic bond. _____

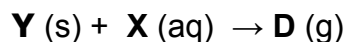
2.2 The boiling point of methanol is 64,7 °C, while the boiling point of iodine is significantly higher at 184,3 °C.

2.2.1 Explain the **origin** of the London intermolecular forces present in iodine. (4)

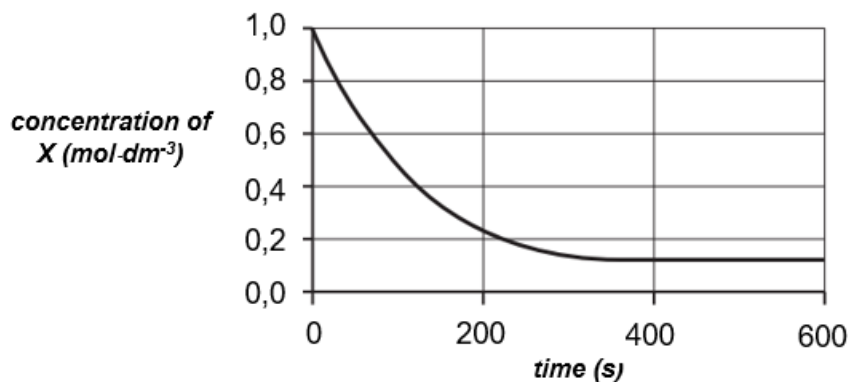
2.2.2 Referring to all intermolecular forces present in the two substances, explain why iodine has a higher boiling point than methanol. (4)

QUESTION 3**[16 marks]**

- 3.1 Solid **pellets** of substance **Y** react with solution **X** to form a gaseous substance **D**. A catalyst was added to the reaction mixture.



The graph below shows how the concentration of **X** changes with time.



- 3.1.1 Identify the limiting reagent in this reaction. Refer to the graph to explain your answer. (3)

- 3.1.2 Describe how the rate of the reaction changes as the reaction proceeds. (2)

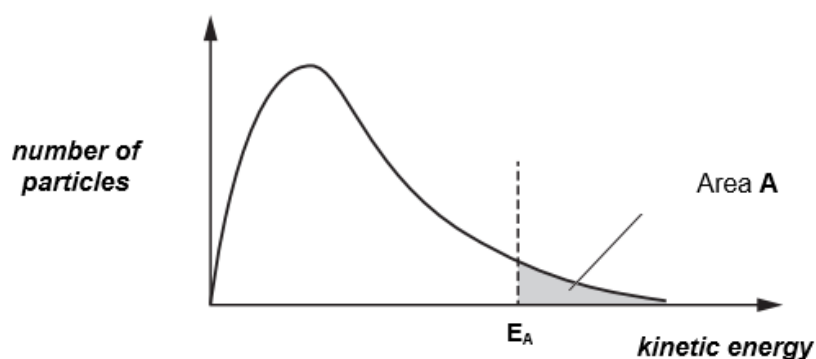
- 3.1.3 What is the function of the catalyst? (1)

- 3.1.4 Use the collision theory to explain how an increase in temperature will increase the rate of the reaction. (4)

3.1.5 On the graph on page 8, draw another line to show how the concentration of **X** will change with time if **half the amount** of **powdered Y** is used, while all the other factors remained constant. (2)

3.1.6 Describe one practical method other than the change in concentration that can be used to determine the rate of this reaction. (2)

3.2 The diagram below shows the Maxwell-Boltzmann distribution of energies of **Y** and **X** at temperature **T**, without the addition of a catalyst.



3.2.1 Annotate the diagram above to show the effect of adding the catalyst to **Y** and **X** at temperature **T**. (1)

3.2.2 Area **B** (not labelled on the given diagram) represents the number of particles with energy greater than or equal to the activation energy when the catalyst is added at temperature **T**.

State the difference, if any, between areas **A** and **B**.

Circle the correct option below. (1)

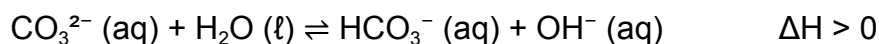
Area **B** will be

THE SAME	LARGER	SMALLER
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 than area **A**.

QUESTION 4**[22 marks]**

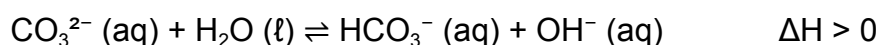
The following equilibrium reaction occurs in the blood and plays an important role in maintaining the correct pH level.



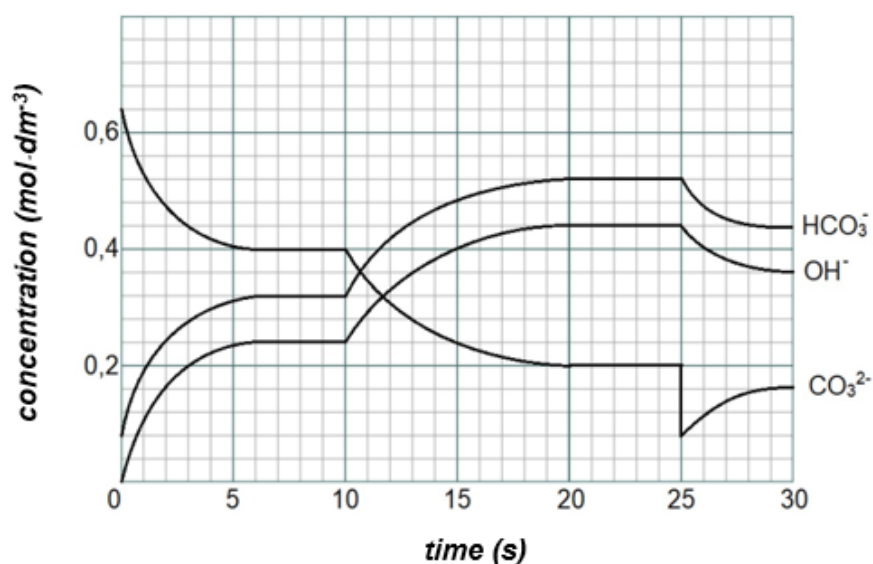
4.1 Explain what is meant by a *dynamic chemical equilibrium*. (2)

4.2 If the blood were to become more acidic, use Le Châtelier's Principle to explain how the alkalinity of the blood would be restored. (3)

To investigate this equilibrium, aqueous solutions of carbonate and hydrogen carbonate were sealed in a container and allowed to reach equilibrium.



The graph below shows how the concentrations change over time.



4.3 Which reaction rate is higher at 3 seconds? Circle the correct option below. (1)

Rate of the forward reaction	Rate of the reverse reaction
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4.4 Explain your answer in 4.3 using the collision theory. (3)

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

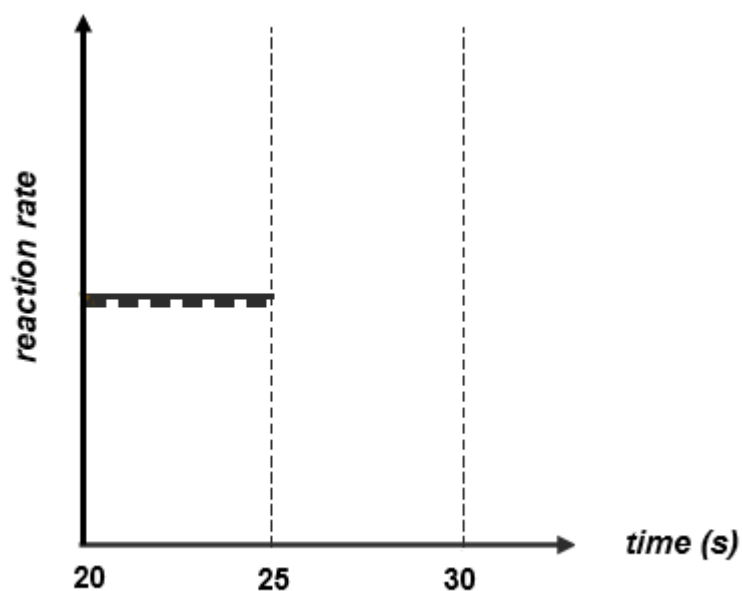
4.6 Calculate the equilibrium constant at 23 seconds. (2)

4.7 Without any additional calculation, state how the K_c value at 7 seconds will compare to the K_c value at 23 seconds, as calculated in Question 4.6. Refer to the change taking place at 10 seconds to explain your answer. (4)

4.8 State the change that occurs at 25 seconds.

(2)

4.9 After the change is made at 25 seconds, equilibrium is reestablished before 30 seconds. On the axes below, show how the reaction rates will be affected between 25 and 30 seconds. The dotted line represents the forward reaction. (3)



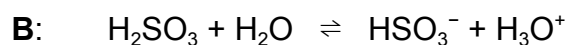
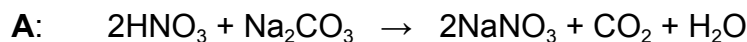
ADDITIONAL SPACE (ALL QUESTIONS)

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

PLEASE TURN OVER FOR QUESTION 5

QUESTION 5**[35 marks]**

5.1 Consider the following balanced chemical equations:



5.1.1 Name the following substances.

H_2SO_3 (aq) _____

NaNO_3 _____ (2)

5.1.2 It is stated that the acid in reaction **A** is a strong acid since it dissociates completely. There is one error in this statement. State this error and give a reason for your answer. (2)

5.1.3 Explain why the acid in **A** will have a higher conductivity than the acid in **B**. (2)

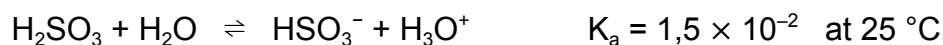
5.1.4 Water is an *amphoteric substance*.

a) What is meant by the term *amphoteric substance*? (1)

b) Give the formula of another amphoteric substance in reactions **A** or **B**. (1)

c) Give the formula of the conjugate base of the substance mentioned in (b). (1)

5.1.5 H_2SO_3 ionises as shown in equation **B**:

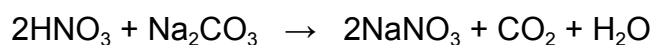


The initial concentration of a solution of the acid is $0,045 \text{ mol} \cdot \text{dm}^{-3}$.

- a) Calculate the equilibrium concentrations of H_2SO_3 and H_3O^+ in this solution at 25°C . (Do not make any approximations.) (5)

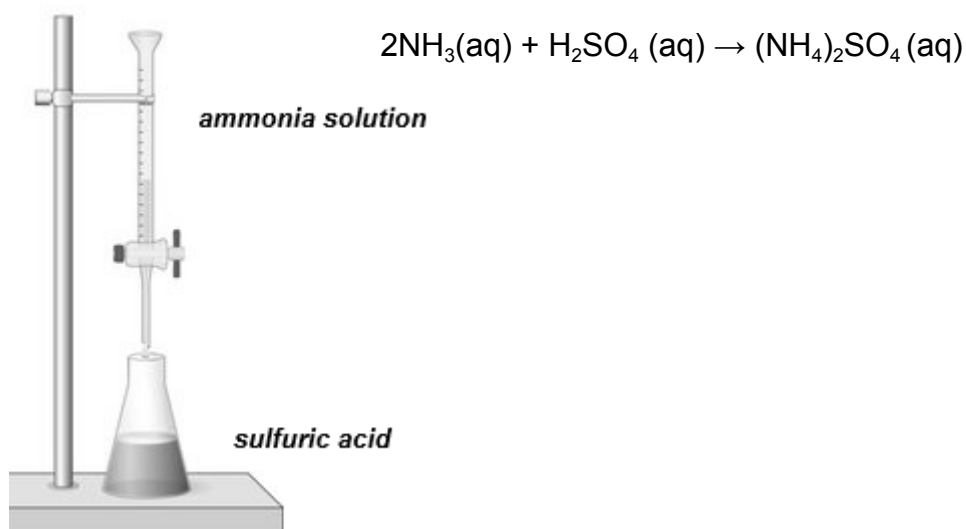
- b) Hence, calculate the concentration of the hydroxide ions in this solution at 25°C . (3)

5.1.6 25 g of a very impure sample of Na_2CO_3 reacts completely with a solution of HNO_3 according to equation **A**, repeated below:



0,165 moles of sodium nitrate are produced.
Calculate the percentage purity of the sample of Na_2CO_3 . (5)

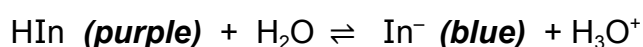
- 5.2 Tokollo performed a titration between a solution of NH_3 and a $0,0312 \text{ mol} \cdot \text{dm}^{-3}$ solution of H_2SO_4 as shown by the reaction equation and diagram below. He transferred $20,00 \text{ cm}^3$ of the sulfuric acid into a conical flask.



5.2.1 Name the apparatus containing the NH_3 solution. (1)

5.2.2 Name the apparatus that Tokollo should have used to transfer the $20,00 \text{ cm}^3$ of sulfuric acid into the conical flask. (1)

5.2.3 The equation below shows the equilibrium reaction for the indicator used in this titration.



Use this to state the colour of the solution in the conical flask. (2)

5.2.4 Define *neutralisation*. (2)

- 5.2.5 Predict the end point pH. Use a suitable balanced hydrolysis equation to aid your answer. (3)
Circle the correct answer:

The pH at the end point will be...

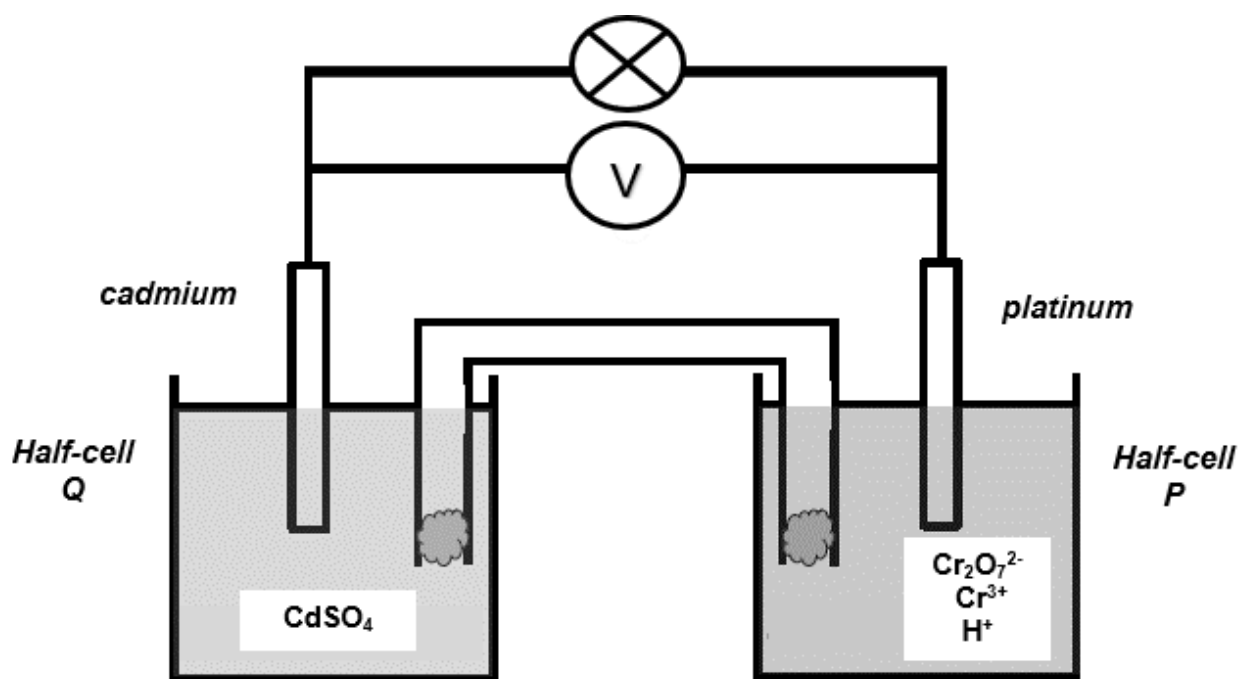
7	less than 7	greater than 7
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- 5.2.6 When the equivalence point was reached, a volume of 32,75 cm³ of the ammonia solution had been used.
Calculate the concentration of the ammonia solution.
Give your final answer to 4 decimal places. (4)

QUESTION 6

[19 marks]

A student constructs a galvanic cell as shown in the diagram below.



6.1 Define a *redox reaction*.

(1)

6.2 In the spaces below, write equations for the oxidation half-reaction, the reduction half-reaction and the net ionic reaction taking place in this cell.

(6)

Oxidation half-reaction:

Reduction half-reaction:

Net ionic reaction:

- 6.3 Circle the option below that correctly describes the path and direction in which the electrons will move. (1)

From half-cell P to Q through the salt bridge	From half-cell Q to P through the salt bridge
From half-cell P to Q through the light bulb	From half-cell Q to P through the light bulb

- 6.4 Calculate the initial EMF of this cell under standard conditions. (3)

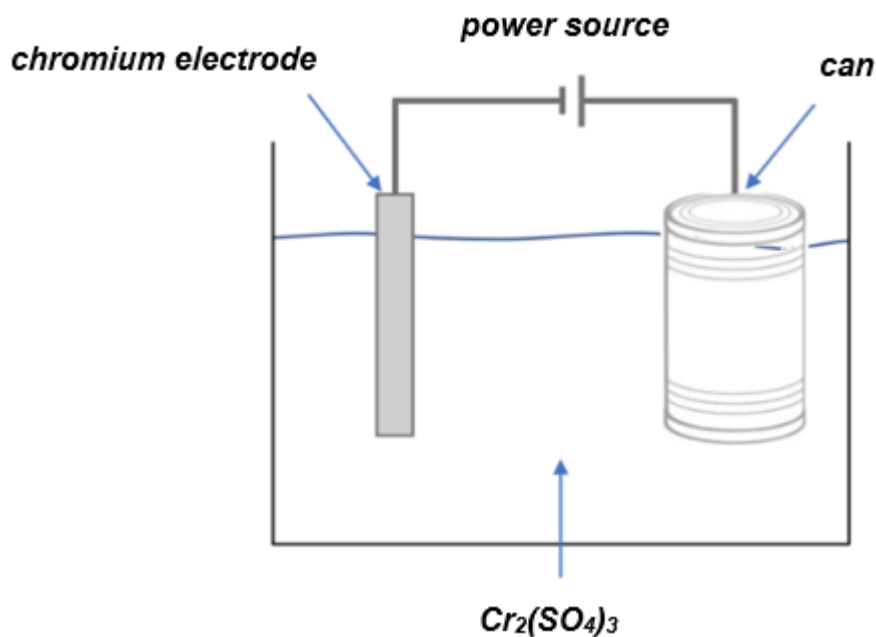
- 6.5 The salt bridge contains an aqueous solution of KNO_3 . Explain how the salt bridge maintains the electrical neutrality in half-cell **Q**. (2)

- 6.6 State how the brightness of the lightbulb would be affected if a shorter salt bridge were used. Explain your answer. (3)

- 6.7 Use cell notation to represent this galvanic cell. No phase labels or conditions need to be shown. Note that the H^+ ions in half-cell **P** should be included. (3)

QUESTION 7**[17 marks]**

Car wheels can be plated using electrolysis of a chromium(III) sulfate solution. Thomas decided to test this in the lab using an inert metal can instead of a wheel. The chromium electrode and the can were placed in a solution of chromium(III) sulfate and connected to a power source as shown in the diagram below.



- 7.1 The concentration of the chromium(III) ions in the solution was $0,5 \text{ mol} \cdot \text{dm}^{-3}$. Calculate the mass of solid $\text{Cr}_2(\text{SO}_4)_3$ that was used to prepare $1,3 \text{ dm}^3$ of the solution. (4)

- 7.2 State the energy conversion taking place during electroplating. (2)

7.3 As soon as the cell started operating, gas bubbles were observed forming on the can.

- Identify the error that was made in setting up this cell that resulted in a gas forming on the can instead of chromium. (1)
- Explain why the gas formed by referring to the table of standard electrode potentials. (1)
- Write the equation for the half-reaction that shows what gas was formed. (2)

7.4 Once the error was corrected, the mass of the chromium electrode decreased by 12 g over a time period of 130 minutes, while chromium metal formed on the can.

7.4.1 Does the mass **loss** take place at the cathode or the anode? Circle the correct answer below. (1)

anode	cathode
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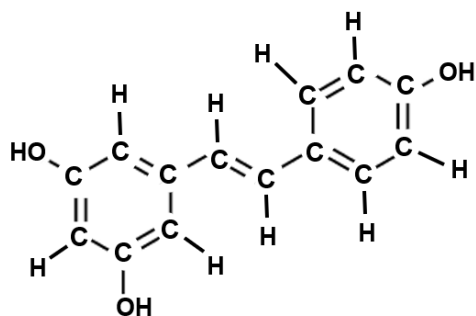
7.4.2 Write the equation for the half-reaction responsible for the loss in mass. (1)

7.4.3 Calculate the average current provided by the power source during the 130 minutes. (5)

QUESTION 8

[22 marks]

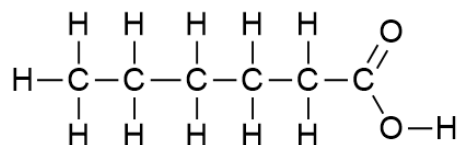
- 8.1 Red wine contains the organic compound resveratrol. The structure of resveratrol is shown below:



- 8.1.1 Define a *functional group*. (2)

- 8.1.2 The carbon-carbon double bond represents one functional group in the structure. Highlight/circle another functional group in the structure above and write the name of this functional group in the space below. (2)

- 8.2 Consider the structural formula below.



- 8.2.1 Give the IUPAC name of the compound. (2)

- 8.2.2 Define *structural isomers*. (2)

- 8.2.3 Draw and name the structural formula for a **functional** isomer of the given structure. (4)

Structural formula:

Name:

8.3 Consider the compounds 1-chloropentane and 2-chloro-2-methylbutane.

8.3.1 These compounds have the same molecular formula. Write down this molecular formula. (2)

8.3.2 Define a *homologous series*. (2)

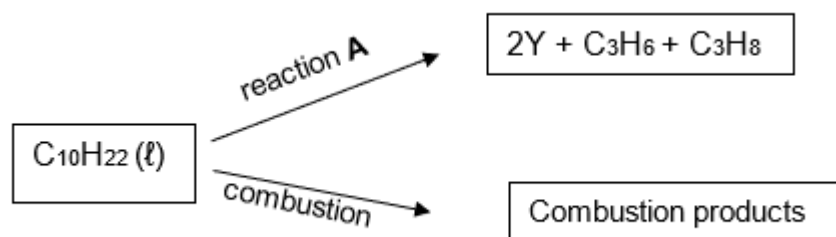
8.3.3 State the homologous series to which these two compounds belong. (1)

8.3.4 1-chloropentane has a boiling point of 108 °C, and 2-chloro-2-methylbutane a boiling point of 86 °C. With reference to all of the intermolecular forces present, explain the difference in these boiling points. (5)

QUESTION 9

[33 marks]

- 9.1 The compound $C_{10}H_{22}$ undergoes two different reactions when heated under different conditions.



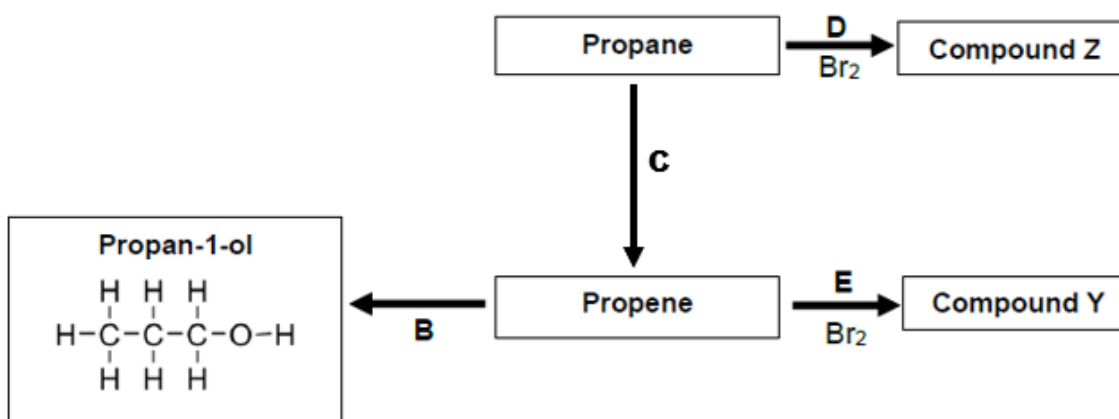
- 9.1.1 Can $C_{10}H_{22}$ be considered to be a *saturated* compound? Explain your answer. (2)

- 9.1.2 State the GENERAL type of reaction taking place in reaction A. (1)

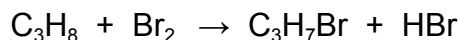
- 9.1.3 Deduce the formula of compound Y. (2)

- 9.1.4 Write a balanced reaction equation for the complete combustion of $C_{10}H_{22}$. Use molecular formulae. (3)

- 9.2 Use the diagram below to answer the questions that follow. The letters **B** to **E** represent organic chemical reactions.



- 9.2.1 The equation below represents the balanced equation for Reaction **D**.
The reaction takes place in the presence of ultraviolet light.

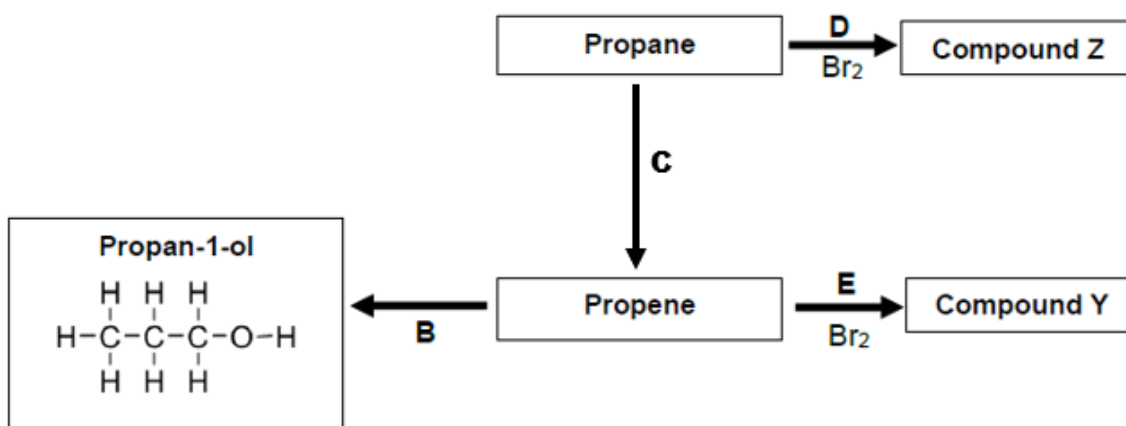


- a) State the GENERAL reaction type shown by Reaction **D**. (1)

- b) 520 cm³ of gaseous C₃H₇Br was produced at 75 °C, at which temperature the molar gas volume (V_m) is 28,6 dm³. The reaction has a yield of 82 %. Calculate the number of C₃H₈ molecules that were initially present. (5)

- 9.2.2 In Reactions **D** and **E**, the reactants are treated with bromine water in the test for unsaturation. Making use of **another** relevant chemical equation, explain the difference in observations between Reaction **D** and Reaction **E**. (4)

The diagram is repeated here for ease of reference.



9.2.3 State the SPECIFIC type of reactions shown by:

Reaction **B**: _____

Reaction **C**: _____ (2)

9.2.4 Compound **Z** ($\text{C}_3\text{H}_7\text{Br}$) is heated under reflux with dilute aqueous NaOH.

a) Write a balanced equation using **molecular** formulae for the reaction that takes place. (3)

b) State the SPECIFIC type of reaction that takes place in (a). (1)

c) State why it is important that the heating of organic substances takes place under reflux. (2)

9.2.5 The propan-1-ol formed in reaction **B** can be used to form propyl butanoate.

a) Name the homologous series that propyl butanoate belongs to. (1)

b) Name the other organic reactant that must be used to form propyl butanoate. (2)

c) Write a balanced equation using **structural** formulae to represent this reaction. (4)

ADDITIONAL SPACE (ALL QUESTIONS)

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

QUESTION 1

MULTIPLE CHOICE QUESTIONS

[2 x 10 = 20]

- 1.1 B ✓✓ $\text{Fe}^{3+} + \text{S}^{2-}$
- 1.2 A ✓✓ A: $28/28 = 1 \text{ mol N}_2 \text{ gas}$ B: $44,8/22,4 = 2 \text{ mol}$
C: $80/40 = 2 \text{ mol}$ D: $36/18 = 2 \text{ mol}$
- 1.3 C ✓✓ it is ionic
- 1.4 D ✓✓ Since yield increases, more H_2O_2 must have been added.
Overall concentration will decrease $\therefore$ rate decreases
- 1.5 B ✓✓ Exo $\therefore$ cooling favours forward
Fewer moles gas on RHS $\therefore$ increasing pressure favours forward
- 1.6 D ✓✓ proton (H^+) donor
- 1.7 D ✓✓ reactions involving elements are always redox (ON must change)
- 1.8 A ✓✓ Co is stronger RA than Sn and Cu; Au will not react
- 1.9 A ✓✓ CH_3 -branch forms part of longest chain
- 1.10 C ✓✓ elimination of HBr to form an alkene

QUESTION 2

[16 marks]

- 2.1.1 A measure of the tendency of an atom to attract a bonding pair of electrons ✓✓ (2)
- 2.1.2 An intermolecular force is a force of attraction between molecules (or atoms of noble gases). ✓
A chemical bond is a bond between atoms within molecules. ✓ (2)
- 2.1.3 a) A ✓
b) C ✓
c) E ✓
d) F ✓ (4)
- 2.2.1 Nonpolar molecule - constantly moving electrons ✓
Momentarily more electrons on one side of the molecule causing a temporary dipole. ✓
The positive side of the temporary dipole induces a dipole in a neighboring molecule. ✓
Opposite sides attract. ✓ (4)
- 2.2.2 Iodine (symmetrical) - only London IMFs
Methanol (polar) - H-bond ✓ and London IMF
Iodine has more electrons ✓ - therefore form more/larger/stronger induced dipoles.
The London IMFs in iodine stronger than the IMFs in Methanol ✓
Therefore more **energy** needed to overcome these forces. ✓
Higher boiling point (4)

QUESTION 3 [16 marks]

- 3.1.1 Y is the limiting reagent. ✓
X decreases in concentration but not to zero ✓
so there is some left (it is not all used up) and therefore it is in excess. ✓ (3)
- 3.1.2 The rate (is fast at the start, then) decreases as the reaction proceeds ✓,
then becomes zero ✓ (when the LR is used up.) (2)
- 3.1.3 It speeds up the reaction ✓ (but is unchanged at the end of the reaction) (1)
- 3.1.4 Increase in temperature causes higher kinetic energy of the reacting particles /
particles move faster. ✓
More collisions take place ✓
and more particles will have E_k higher or equal to the activation energy. ✓
More effective collisions will take place per unit time. ✓
Faster reaction rate. (4)
- 3.1.5 Line with steeper gradient ✓ and half the concentration change (half of 0,9 = 0,45,
thus should decrease to 0,55) ✓ shown. (2)
- 3.1.6 Collect the gas formed using a syringe (or downward displacement of water
with inverted measuring cylinder) and measure the volume (*method + apparatus* ✓)
at different time intervals ✓ using a stop watch /determine the volume vs time
OR place on a scale and measure the mass loss at different time intervals. (2)
- 3.2.1 E_a line shifts to the left. ✓ (1)
- 3.2.2 Area B will be LARGER than Area A ✓ (1)

QUESTION 4 [22 marks]

- 4.1 A reversible reaction in which the forward and the reverse reactions are taking place
at the same rate, ✓ and hence the concentrations of reactants and products are
constant. ✓ (2)
- 4.2 Stress - decrease in concentration of hydroxide ions ✓
According to LCP the forward reaction will be favoured, ✓
to increase the concentration of the hydroxide ions ✓
thus restoring the alkalinity of the blood. (3)
- 4.3 Rate of the forward reaction. ✓ (1)
- 4.4 Before first equilibrium there are more reactant particles than product particles. ✓
More **reactant** collisions per unit time. ✓
More effective collisions for forward reaction per unit time ✓ so faster rate. (3)

$$4.5 \quad K_c = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}]} \quad \checkmark \text{top} \checkmark \text{bottom no water (-1 if no square brackets)} \quad (2)$$

$$4.6 \quad K_c = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}]} = \frac{(0,52)(0,44)}{(0,2)} \quad \checkmark$$

$$= 1,14 \quad \checkmark \quad (2)$$

4.7 The reaction is endothermic and according to the graph the forward reaction is favoured. $\checkmark$

This means that the change was an increase in temperature $\checkmark$ and temperature does affect the K_c .

More products are formed (yield increases) $\checkmark$ so the K_c value will increase after the increase in temperature.

K_c value at 7 seconds will be less than the K_c value at 23 seconds. $\checkmark$ (4)

4.8 A decrease $\checkmark$ in the concentration of $CO_3^{2-}(aq)$ $\checkmark$ (2)
OR CO_3^{2-} was removed

4.9 Spike down for the forward reaction $\checkmark$
New equilibrium reached where lines meet again $\checkmark$
Final rates lower than initial $\checkmark$
(-1 if both rates spike down at 25s) (3)

QUESTION 5 [35 marks]

5.1.1 Sulfurous acid $\checkmark$
Sodium nitrate $\checkmark$ (2)

5.1.2 It is a strong acid but acids are molecular $\checkmark$ and will ionise and not dissociate.
He should have said **ionise** (almost) completely. $\checkmark$ (2)

5.1.3. Nitric acid is strong and ionises completely - many free ions in solution to conduct electricity. $\checkmark$
Sulfurous acid is weak and only ionises partially - fewer free ions in solution to conduct electricity. $\checkmark$ (2)

5.1.4 a) A substance that can act as either an acid or a base $\checkmark$ (1)

b) HSO_3^- $\checkmark$ (1)

c) SO_3^{2-} (coe) $\checkmark$ (1)

5.1.5 a)

	H_2SO_3	HSO_3^-	H_3O^+
Initial	0,045 ✓initial	0	0
Changed	-x	-x	-x
Equilibrium	0,045-x	x	x ✓end

$$K_a = \frac{[\text{HSO}_3^-][\text{H}_3\text{O}^+]}{[\text{H}_2\text{SO}_3]} \therefore 0,015 = \frac{(x)(x)}{(0,045-x)} \quad \checkmark$$

$$\begin{aligned} x = [\text{HSO}_3^{2-}] = [\text{H}_3\text{O}^+] &= 1,954 \times 10^{-2} \text{ mol} \cdot \text{dm}^{-3} \quad \checkmark \\ [\text{H}_2\text{SO}_3] &= 0,045 - x = 0,045 - (1,954 \times 10^{-2}) \quad \checkmark = 0,02546 \\ &= 2,546 \times 10^{-2} \text{ mol} \cdot \text{dm}^{-3} \end{aligned} \quad (5)$$

$$\begin{aligned} \text{b) } K_w &= [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14} \quad \checkmark \\ (1,954 \times 10^{-2} \text{ coe})[\text{OH}^-] &= 1 \times 10^{-14} \quad \checkmark \\ [\text{OH}^-] &= 5,118 \times 10^{-13} \text{ mol} \cdot \text{dm}^{-3} \quad \checkmark \end{aligned} \quad (3)$$

$$\begin{aligned} 5.1.6 \quad n(\text{NaNO}_3) &= 0,165 \text{ mol} \\ \text{ratio } 2:1 &\quad \checkmark \text{ can be implied} \\ m &= n \times M = (0,165 / 2) \times 106 \quad \checkmark (M) = 8,745 \text{ g} \quad \checkmark (\text{pure Na}_2\text{CO}_3) \\ \% \text{ purity} &= \text{Pure mass} / \text{impure mass} \times 100 \quad \checkmark = (8,745 / 25) \times 100 \\ &= 34,98 \% \quad \checkmark \end{aligned} \quad (5)$$

$$5.2.1 \quad \text{Burette} \quad \checkmark \quad (1)$$

$$5.2.2 \quad \text{Pipette} \quad \checkmark \quad (1)$$

$$5.2.3 \quad \text{purple} \quad \checkmark \checkmark \quad (2)$$

$$5.2.4 \quad \text{A chemical reaction in which an acid and a base react so that neither is in excess} \quad \checkmark \checkmark \quad (2)$$

$$\begin{aligned} 5.2.5 \quad \text{less than } 7 &\quad \checkmark \\ \text{NH}_4^+ + \text{H}_2\text{O} &\quad \checkmark \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+ \quad \checkmark \quad (-1 \text{ if single arrow}) \\ [\text{OH}^-] &< [\text{H}_3\text{O}^+] \end{aligned} \quad (3)$$

$$5.2.6 \quad n(\text{H}_2\text{SO}_4) = c \times V = 0,0312 \times 0,02000 = 6,24 \times 10^{-4} \text{ mol} \quad \checkmark$$

Ratio 1:2

$$\begin{aligned} n(\text{NH}_3) &= 2 \times n(\text{H}_2\text{SO}_4) \\ &= 2 \times 6,24 \times 10^{-4} = 1,248 \times 10^{-3} \text{ mol} \\ c &= n/V = (1,248 \times 10^{-3}) / 0,03275 \\ &= 0,0381 \text{ mol} \cdot \text{dm}^{-3} \end{aligned}$$

Equation ✓
 Sub ✓
 Apply ratio ✓
 Answer with 4 dp ✓

$$\text{OR} \quad \frac{c_a V_a}{a} = \frac{c_b V_b}{b} \quad \frac{0,0312 \times 20}{1} = \frac{c_b \times 32,75}{2} \quad c_b = 0,0381 \text{ mol} \cdot \text{dm}^{-3} \quad (4)$$

QUESTION 6 [19 marks]

- 6.1 (A reaction involving) the transfer of electrons ✓ (1)
- 6.2 Oxidation: $\text{Cd} \rightarrow \text{Cd}^{2+} + 2\text{e}^-$ ✓✓ (-1 if double arrows)
 Reduction: $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$ ✓✓
 Net ionic equation: $3\text{Cd} + \text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ \rightarrow 3\text{Cd}^{2+} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$ ✓✓ (coe) (6)
- 6.3 **Q to P** through the **lightbulb** ✓ (1)
- 6.4 $E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta}$ ✓
 $E_{\text{cell}}^{\theta} = 1,33 - (-0,40)$ ✓ (coe)
 $= 1,73\text{ V}$ ✓ (3)
- 6.5 As reaction/oxidation proceeds, Cd^{2+} ions are formed; therefore, the electrolyte in half-cell Q becomes more positive. ✓
 EITHER
 The negative ions in the salt bridge (NO_3^-) flow into half-cell Q to neutralise charge. ✓
 OR
 Positive ions (Cd^{2+}) move out of half-cell Q into the salt bridge (2)
- 6.6 A shorter salt bridge lowers internal resistance ✓ thereby increasing the maximum current ✓ that the cell can deliver, and the bulb will glow brighter ✓ (3)
- 6.7 $\text{Cd} \mid \text{Cd}^{2+} \parallel \text{Cr}_2\text{O}_7^{2-}, \text{H}^+, \text{Cr}^{3+} \mid \text{Pt}$ (coe from 6.2) (3)
 anode and cathode on correct sides ✓
 correct order of reactants and products (ignore position of H^+) ✓
 Pt electrode in correct place ✓
 (-1 if no double line for salt bridge or incorrect punctuation)

QUESTION 7 [17 marks]

- 7.1 $n(\text{Cr}^{3+}) = c \times V = 0,50 \times 1,3 = 0,65\text{ mol Cr}^{3+}$ ✓
 1 mole of $\text{Cr}_2(\text{SO}_4)_3$ gives 2 moles of Cr^{3+} .
 $n(\text{Cr}_2(\text{SO}_4)_3) = 0,65 / 2$ ✓ = 0,325 mol
 $n = m/M$ $m = 0,325 \times 392$ ✓ = 127,4 g ✓ (4)
- 7.2 Electrical energy to chemical energy ✓✓ (2)
- 7.3 The cell is connected the wrong way. ✓
 The can is inert and sulfate cannot be oxidised
 OR water is the strongest / only RA ✓,
 water will be oxidised forming oxygen gas at the anode.
 $2\text{H}_2\text{O} \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+ + 4\text{e}^-$ ✓✓ (4)

7.4.1 Anode ✓ (1)

7.4.2 $\text{Cr} \rightarrow \text{Cr}^{3+} + 3\text{e}^-$ ✓ (1)

7.4.3 $n_{\text{Cr}} = m/M = 12/52 = 0,231 \text{ mol}$ ✓ (5)

ratio 1:3

$n_{\text{e}^-} = 3 \times 0,231 = 0,693 \text{ mol of electrons}$ ✓

$q = nF$ ✓ *equations* $= 0,693 \times 96500 = 66900 \text{ C}$

$q = It$

$t = 130 \times 60 = 7800 \text{ s}$ ✓

$I = 66900/7800$

$= 8,57 \text{ A}$ ✓

QUESTION 8 [22 marks]

8.1.1 An atom or a group of atoms that form the centre of chemical activity in the molecule. ✓✓ (2)

8.1.2 Highlight one of the OH-s ✓
Hydroxyl group ✓ (2)

8.2.1 Hex✓anoic acid ✓ (2)

8.2.2 Compounds having the same molecular formula ✓ but different structural formulae. ✓ (2)

8.2.3 Ester with 6 carbons - Structure ✓✓
name: methyl pentanoate or pentyl methanoate or ethyl butanoate
or butyl ethanoate or propyl propanoate ✓✓ (*carry over naming if isomer*)
(4)

8.3.1 $\text{C}_5\text{H}_{11}\text{Cl}$ ✓✓ (-1 per error, must be in correct order) (2)

8.3.2 A series of similar compounds which have the **same functional group** and have the same **general** formula, ✓ in which each member differs **from the previous one** by a single CH_2 unit. ✓ (2)

8.3.3 haloalkanes ✓ (1)

8.3.4 Both have London IMFs as well as dipole-dipole IMFs ✓
Straight chain isomer has a greater contact surface area ✓
resulting in larger/greater/more temporary dipoles ✓ *accept more IMF's*
therefore stronger London forces ✓
more energy needed to overcome them ✓ (5)

QUESTION 9 [33 marks]

9.1.1 Yes. ✓ Only single bonds between carbon atoms / it is an alkane ✓ (2)

9.1.2 Elimination ✓ (1)

9.1.3 C₂H₄ ✓✓ (1 for C₄H₈) (2)

9.1.4 2 C₁₀H₂₂ + 31 O₂ → 20 CO₂ + 22 H₂O ✓ reactants ✓ products ✓ balancing (3)

9.2.1 a) Substitution (1)

9.2.1 b) $n = \frac{V}{V_m} = \frac{0,520}{28,6} \checkmark = 0,01818 \text{ mol}$

% yield = $\frac{\text{Actual moles}}{\text{Theoretical moles}} \times 100 \checkmark$

82 = $\frac{0,01818}{\text{Theoretical moles}} \times 100 \checkmark$

theoretical moles = 0,02217 moles C₃H₇Br

moles C₃H₈ = 0,02217 mol (1:1) (may be implied)

$n = \frac{N}{N_A}$

N(C₃H₈) = 0,02217 x (6,02 × 10²³) ✓ = 1,334 × 10²² molecules ✓ (5)

9.2.2 Reaction D (substitution) is slow ✓

The reaction does not take place spontaneously and needs UV as stated.

Without UV the colour remains brown until UV is used then the given reaction takes place.

Reaction E (addition) is fast. ✓

The reaction takes place spontaneously and the colour immediately changes to colourless according to the following equation:

C₃H₆ + Br₂ → C₃H₆Br₂ ✓

Brown (colour disappears ✓) faster in E (4)

9.2.3 Reaction B: hydration ✓

Reaction C: dehydrogenation ✓ (not in SAGS ∴ mark awarded to all) (2)

9.2.4 a) C₃H₇Br + NaOH ✓ → C₃H₇OH ✓ + NaBr ✓ (3)

9.2.4 b) hydrolysis ✓ (1)

9.2.4 c) Organic substances are very volatile / have low boiling points ✓

Reflux needed to condense substances to avoid losses. ✓ (2)

9.2.5 a) esters ✓ (1)

9.2.5 b) butanoic acid ✓✓ (2)

9.2.5 c) USE STRUCTURAL FORMULAE (accept H₂O) (4)

propan-1-ol(given) + butanoic acid ✓ → propyl butanoate ✓✓ + water ✓

(-1 for any missing H's)