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CHEMISTRY MEMORANDUM

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QUESTION 1 – MULTIPLE CHOICE

20 MARKS

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

QUESTION 2 CHEMICAL BONDING

18 MARKS

2.1

- | | |
|---|---------------------------|
| 2.1.1 NH ₃ ✓ | dipole-dipole attraction. |
| 2.1.2 CF ₄ ✓ | |
| 2.1.3 KBr✓ | 2.1.5 KBr✓. |
| 2.1.4 HCl✓. Allow NH ₃ as well because H-bonds are a special type of | 2.1.6 Zn✓ |
| | 2.1.7 NH ₃ ✓ |
| | 2.1.8 CF ₄ ✓ |

(8)

2.2

- 2.2.1 SiO₂✓✓ (2)
- 2.2.2 Intramolecular bond: *occurs between atoms within molecules*✓ (2)
- 2.2.3 One would find the difference ✓ in electronegativity values✓ (of Si and O atoms)
The difference is > 0 so the bonds are polar covalent✓ (3)
 OR
 $\Delta \text{electronegativity} = 3,5 - 1,8 = 1,7 > 0$ ✓
 Therefore polar covalent bond.✓
- 2.2.4 Silicon dioxide forms a **giant molecule** where **all**✓ of the atoms are **bonded covalently**✓ to each other. In carbon dioxide, the **non-polar molecule** contains **only three atoms**✓ and in the solid state the molecules are held together **by London forces.** ✓ (4)

OR

The silicon dioxide has a **tetrahedral shape.** ✓ Giant covalent lattice✓
 Carbon dioxide is a **linear molecule.** Weak intermolecular forces✓ (4)

QUESTION 3 ENERGY AND RATES**28 MARKS**

3.1

3.1.1 **25** or 25,0 or 25,00 ✓✓ (s) (no need to show method)
If correct method shown but incorrect answer then ✓. (2)

3.1.2 **0,4 mol·dm⁻³** solution ✓. (1)

3.1.3 The person doing the experiment takes **multiple readings that are similar** ✓, but his reaction time is **not good / faulty** stop watch ✓ (2)

3.1.4 Rate = $\frac{1}{(\text{average}) \text{ time}}$ ✓✓ or rate = (average) time⁻¹ ✓✓

IFRate = $\frac{\Delta c}{\Delta t}$

Δt ✓ (1 out of 2) (2)

3.1.5 SEE ATTACHED MEMORANDUM OF THE ANSWER SHEET BELOW

(a) all values correct ✓✓ (2)

(b) 3 points plotted correctly ✓✓✓ (-1 for each incorrect pt)
straight line with a ruler ✓
through the origin ✓ (5)

3.1.6

(a) directly proportional ✓✓
OR
The rate of reaction is directly proportional to the concentration of the sodium thiosulphate solution. ✓✓ (2)

(b) inversely proportional ✓✓
OR
The time taken for the solution to become too cloudy (accept “for the cross to disappear”) is inversely proportional to the concentration of the sodium thiosulphate solution. ✓✓ **OR**

The time taken for the solution to become too cloudy (accept “for the cross to disappear”) is directly proportional to the inverse of the concentration of the sodium thiosulphate solution. ✓✓

ACCEPT:

The concentration of thiosulphate is inversely proportional to the time taken for the solution to become too cloudy.

The concentration of thiosulphate is directly proportional to the rate of the reaction.

A conclusion referring to rate is INCORRECT as the question explicitly asks for a time reference. (Only 1 out of 2) (2)

3.2.

3.2.1 SEE ATTACHED MEMORANDUM OF THE ANSWER SHEET ON NEXT PAGE

Straight line from the origin✓

at a higher gradient than 3.1.4 (b).✓ (2)

3.2.2 A decrease in temperature will decrease the (average) kinetic energy of the particles✓

Less particles will have kinetic energy (equal to or) greater than the activation energy/Less particles colliding with the correct orientation ✓

This will lead to fewer effective collisions per unit time (second)✓
which leads to a slower (decreased) reaction rate✓. (4)

3.3

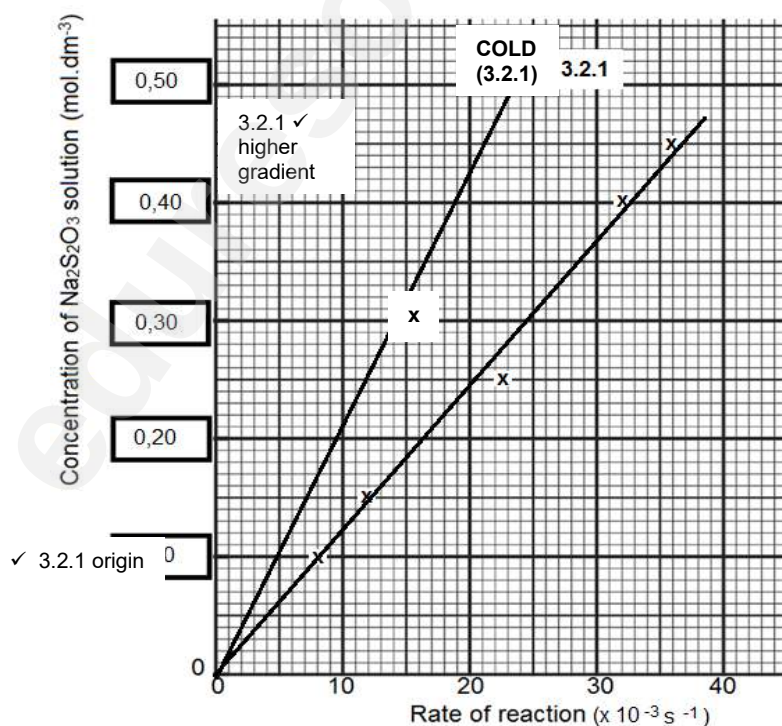
3.3.1 More sulphur (or solid or precipitate) will form between his eyes and the cross (every second) ✓✓ as he has more of the reacting solutions between his eyes and the cross.

Reference to the rate being higher is INCORRECT. (2)

3.3.2 10 (seconds)✓ (2)

QUESTION 3.1.4 (a), (b) and 3.2.1.

GRAPH OF THE CONCENTRATION OF $\text{Na}_2\text{S}_2\text{O}_3$ SOLUTION VS THE RATE OF REACTION WITH HYDROCHLORIC ACID



QUESTION 4 CHEMICAL EQUILIBRIUM**30 MARKS**

4.1

4.1.1 A system in which mass is conserved inside the system ✓ ✓ Accept any correct description of a closed container where particles cannot enter or leave/ no reactant or product can escape. Any reference to energy being conserved is INCORRECT. (2)

4.1.2 Dynamic equilibrium is reached in a chemical reaction in which the forward and reverse reactions ✓ (continue to) take place (simultaneously) at the same rate ✓.

OR Rate of forward reaction = rate of reverse reaction

OR Dynamic chemical equilibrium is reached when the concentration of the reactants and products ✓ remains constant ✓ OR "is in a constant ratio." (2)

4.1.3 When an external stress is applied to a system in chemical equilibrium ✓, the equilibrium point ✓ will change in such a way as to counteract the stress ✓. (3)

4.1.4 (a) The particles became more spread out/ the density of the mixture decreased/ (as the volume increased) the concentration decreased/ fewer moles of NO₂ per unit volume ✓ (2)

(b) According to Le Chatelier's principle

- The volume increased, causing the pressure to decrease ✓
- Which will favour the reverse reaction/ equilibrium position shifts to the left ✓
- Which produces more moles of gas/ the concentration of NO₂ increases/more dark brown particles form ✓
- And therefore relieves the stress of low pressure ✓ (4)

NOTE: If they say increase volume without mentioning the decrease in pressure then no marks for explanation.

NOTE: Give mark for correct inverse relationship between volume and pressure.

OR

The reverse reaction was favoured ✓ (Equilibrium shifts to the left) to produce more moles of gas ✓ which relieves the stress of the lowered pressure (or in order to increase the pressure again) ✓ Thus more dark brown particles are made ✓ (4)

4.1.5 (a) INCREASED ✓ (1)

(b) Exothermic ✓ (1)



(c) - increase in temperature favours the endothermic reaction ✓
 - The reverse reaction is favoured and is thus endothermic ✓
 - in order to relieve the stress of the increase in temperature to absorb the thermal energy ✓ (Therefore the forward reaction is exothermic)

OR

- The increase in temperature favoured the reverse reaction ✓ OR shifted the equilibrium position to the left (as shown by the colour change)
- An increase in temperature will cause the endothermic reaction to be favoured in order to absorb the thermal energy to reduce the stress on the system / favouring the endothermic reaction when temperature increases helps to reduce the effect of the stress on the system by absorbing the thermal energy ✓
- Thus the reverse reaction is endothermic ✓. (Therefore the forward reaction is exothermic) (3)

4.2 4.2.1 $K_c = \frac{[AB_3]^2}{[A_2].[B_2]^3}$ ✓✓ round brackets subtract 1 mark (2)



4.2.2

+

Ratio	1 A ₂	3 B ₂	2 AB ₃
Initial (mol)	6	6	1
Change (mol)	-1,5	-4,5	+3 ratio✓
Equilibrium (mol)	4,5	1,5 ✓	4
Equilibrium concentration	2,25✓	0,75✓	2

OR At equilibrium:

$$[A_2] = 2,25 \text{ mol} \cdot \text{dm}^{-3} \quad \checkmark \checkmark$$

$$[B_2] = 0,75 \text{ mol} \cdot \text{dm}^{-3} \quad \checkmark \checkmark$$

$$([AB_3] = 2 \text{ mol} \cdot \text{dm}^{-3} \text{ No marks – given})$$

(4)

4.2.3 c.o.e from 4.2.2 and 4.2.1

$$K_c = \frac{(2)^2}{(2,25) \cdot (0,75)^3} \quad \checkmark \text{ for correct substitutions}$$

$$= 4,21 \checkmark$$

accuracy; no units

(2)

4.2.4 Increase in pressure

(2)

4.2.5 (a) STAYS THE SAME

(1)

(b) DECREASE

(1)

QUESTION 5 ACIDS AND BASES

19 MARKS

5.1

5.1.1 Strong base: A base that dissociates almost completely in an aqueous solution ✓ (2)

5.1.2 $\text{KOH(s)} \rightleftharpoons \text{K}^+(\text{aq}) + \text{OH}^-(\text{aq})$ state symbols all correct ✓

Do not penalise for single arrow $\rightarrow$

Could write H_2O on single or double arrow

If extra water on the RHS as a product (-1) (3)

5.1.3 $K_w = [\text{H}_3\text{O}^+(\text{aq})][\text{OH}^-(\text{aq})]$ ✓ (method)

$[\text{H}_3\text{O}^+] = \frac{10^{-14}}{x}$ ✓ $\text{mol}\cdot\text{dm}^{-3}$ (accuracy; no penalty for SI units)

If correct answer given with no working award ✓✓

Accept $[\text{H}_3\text{O}^+] = \frac{K_w}{x}$ $\text{mol}\cdot\text{dm}^{-3}$ ✓✓ (2)

5.1.4

- There is a greater current flowing in the KOH solution ✓

/ the current through the bulb is greater

(must refer to current strength somehow – not brightness of the bulb)

- Higher concentration of ions in the KOH solution ✓
- The bulb shines brighter in the stronger the base/ better conductor of electricity ✓ (3)

5.2.1 Hydrolysis is a reaction of an ion (from a salt) with water ✓✓ (2)

5.2.2 $n(\text{H}_2\text{SO}_4) = c \cdot V = (0,25)(8,75 \times 10^{-3}) = 2,1875 \times 10^{-3} \text{ mol}$ ✓

Ratio: 1 : 1

$n((\text{NH}_4)_2\text{SO}_4) = n(\text{H}_2\text{SO}_4) = 2,1875 \times 10^{-3} \text{ mol}$ ✓

$m((\text{NH}_4)_2\text{SO}_4) = n \cdot M$

$M((\text{NH}_4)_2\text{SO}_4) = (18 \times 2 + 32 + 64) = 132$

$= (2,1875 \times 10^{-3})(132)$ ✓ $= 0,29 \text{ g}$ ✓ (0,28875)

(4)

5.2.3 The ammonium ion from the salt will react with hydroxide ions in water to form ammonia molecules and water, ammonium hydroxide is a weak base.

The decrease in $[\text{OH}^-]$ is a stress on the equilibrium in water ✓

According to Le Chatelier's principle, the system works to overcome or reduce the stress and the forward reaction is favoured to replace the OH^- ions. ✓

This increases the concentration of the hydronium ions and the pH decreases to less than 7. ✓ (3)

QUESTION 6 GALVANIC CELLS

24 MARKS

6.1

6.1.1 All solutions (have a concentration of) $1 \text{ mol} \cdot \text{dm}^{-3}$ ✓ and at a (temperature) of $25^\circ\text{C}/298\text{K}$ ✓

Do not accept a pressure of 1 atm. (2)

6.1.2 $\text{emf} = E^\ominus_{\text{cathode}} - E^\ominus_{\text{anode}}$
 $= 0,34 - (-0,76)$ ✓ substitution
 $= +1,10\text{V}$ ✓ (accuracy; SI units) (2)

6.1.3

(a) The anode corrodes (away). ✓ (not oxidises)
 Accept the anode "gets eaten away", "loses mass", "dissolves". (2)

(b) $\text{Zn} \rightarrow \text{Zn}^{2+} + 2 \text{e}^-$ ✓✓ (-1 if double arrow used) (2)

(c) LEFT ✓ (2)

6.1.4

(a) electrons. ✓ (2)

(b) ions ✓ (accept anions and cations) (2)

6.1.5 B (Decrease) ✓ (2)

6.2.1 The ions are free to flow ✓ in the solution keeping the solution surrounding each electrode neutral ✓

OR Electrodes are in the same solution ✓ and ions are free to move. ✓

OR Both electrodes share the same electrolyte solution ✓ thus as charges are removed at the one electrode, they are replaced into the electrolyte solution at the other electrode at the same rate. ✓ (2)

6.2.2 Oxidising agent is a *substance that takes electrons and is itself reduced* ✓✓ (2)

6.2.3 stronger ✓✓ (X is a stronger reducing agent than Q)
When paired with J it produces a greater cell voltage ✓ (than Q does) (3)

6.2.4 Z ✓ (1)

QUESTION 7 ELECTROLYTIC CELLS

21 MARKS

7.1 Electrical → chemical ✓. (2)

7.2 So that the ions are free to move ✓
Do not accept "so that they can conduct electricity". (2)

7.3 Negative ✓
Subtract 1 for double arrows once only unless this has already been done in 6.1.3(b) (2)

7.4

7.4.1 $\text{Na}^+(\ell) + e^- \rightarrow \text{Na}(\ell)$ ✓ (correct state) ✓ (2)

7.4.2 $2\text{H}_2\text{O} + 2e^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-$ ✓✓ (2)

7.4.3 In Cell 2 the water is a stronger oxidising agent than the Na^+ ions ✓ (or converse) and so H_2O reduces in preference to the Na^+ ions. ✓

OR different substances ✓ are being oxidised and reduced in the different cells. ✓ (2)

7.5

7.5.1 Chlorine: $n = V/V_m$ ✓ method
= 0,056/22,4 ✓ substitution
= $2,5 \times 10^{-3}$ mol. ✓ (3)

⊕ If incorrect conversion

7.5.3 Ratio Cl_2 : Na is 1:2
 $n_{\text{electrons}} = 2 \times n(\text{Cl}_2)$ ✓
= $2 \times 2,5 \times 10^{-3}$
= 5×10^{-3} electrons (3)

7.5.4 $Q = n_{\text{electrons}} \times F$
= $5 \times 10^{-3} \times 96500$
= 482,5 C ✓

$$I = Q/t$$

$$= 482,5 / 120 \checkmark$$

$$= 4,02 \text{ A} \checkmark \text{ (accuracy; SI units)}$$

$$\text{OR } Q = n_{\text{electrons}} \times N_A \times e^-$$

$$= 5 \times 10^{-3} \times 6,02 \times 10^{23} \times 1,6 \times 10^{-19}$$

$$= 481,6 \text{ C} \checkmark$$

$$I = Q/t = 481,6 / 120 \checkmark = 4,01 \text{ A} \checkmark \quad (4)$$

QUESTION 8**40 MARKS**

8.1

8.1.1 Functional group: an atom or a group of atoms ✓ that form the centre of chemical activity in the molecule ✓ (2)

8.1.2 Double (covalent) bond ✓ between carbon atoms ✓ (2)

8.1.3

- As the size of the molecule increases/ as the length of the carbon chain increases/ as the molecular mass increases/ as the surface area increases as you go down the group ✓
- The London forces/ dispersion forces / induced/temporary/momentary dipole forces found between the molecules increase in strength / there are **more** induced/ temporary/ momentary dipole forces or London forces or dispersion forces. ✓
- More energy is needed to overcome the stronger/more London forces or to separate the molecules ✓
- therefore a higher boiling point ✓ (4)

OR

The intermolecular forces experienced are London forces or dispersion forces or induced/temporary/momentary dipole forces/ Therefore **more** induced/ temporary/ momentary dipole forces or London forces or dispersion forces. ✓

Bigger molecules have (more atoms and hence) more electrons **OR** a greater surface area ✓

More energy is needed to overcome the stronger intermolecular forces (**NOT bonds**) or to separate the molecules ✓

therefore a higher boiling point ✓ (4)

8.1.4 For molecules with the same number of carbon atoms✓ the boiling points of the alkenes are lower than those of the alkanes✓

OR

For molecules with the same number of carbon atoms✓ the alkanes have a higher boiling point than the alkenes✓ (2)

8.2

8.2.1 A compound containing (only) carbon and hydrogen atoms ✓in which there are only single bonds ✓between carbon atoms✓. (3)

8.2.2

- Water has relatively strong hydrogen bonding ✓ between its molecules
- While the hydrocarbon has weaker London forces between its molecules ✓
- Thus, the intermolecular forces are not of similar strength ✓
(and so the hydrocarbon is not miscible in water.) (3)

✓ names of IMF

✓ comparison

✓ not of similar strength

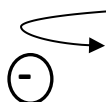
OR

Water is polar and the hydrocarbon is non-polar✓

Their IMFs are not of similar strength.✓

The hydrogen bond forces between water particles are so strong✓ that the hydrocarbon particles are pushed out. (3)

8.2.3 Not valid ✓



- Octanol has a relatively long carbon chain and is mainly a non-polar molecule and although it has a hydrogen bond, it experiences mainly London forces between its molecules ✓
- And so octanol would not be miscible like the alcohol in the diagram✓(3)

OR

So the solubility of the octanol molecules would be dependent on its predominantly non-polar nature OR the octanol molecules would experience predominantly London/ induced dipole forces not hydrogen bond forces✓

And so octanol would not be miscible like the alcohol in the diagram✓(3)

8.3

8.3.1 (a) A chemical process✓

New products are formed✓

OR bonds are broken (2)

(b) $C_{18}H_{38} \rightarrow C_{12}H_{26} + 3 \checkmark C_2H_4$ (nothing else must be changed) (2)

8.3.2 (a) Combustion OR (rapid) oxidation✓. (1)

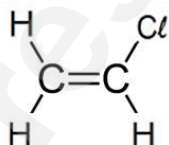
(b) $C_2H_4 + 3O_2 \checkmark \rightarrow 2CO_2 + 2H_2O \checkmark$ (2)

8.3.3 (a) Chlorine (gas)✓ (reject the formula) (1)

(b) 1,2-dichloroethane. 1,2 - ✓ dichloro✓ ethane✓
(- 1 for convention error e.g. gaps, no commas etc)

CH_2ClCH_2Cl ✓ (4)

(c)



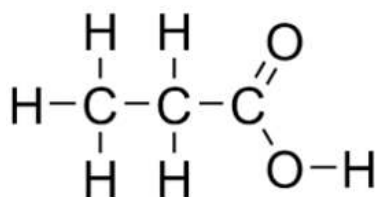
✓ double bond between two carbons

✓ whole molecule (2)

8.3.4 (a) Addition OR hydration ✓ (1)

(b) Methanoic acid ✓✓ (2)

(c) Propanoic acid ✓✓



✓ functional group ✓ whole molecule

(4)