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QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice Answer Sheet provided. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

1.1 B ✓✓

1.2 A ✓✓

1.3 A ✓✓

1.4 D ✓✓

1.5 A ✓✓

1.6 A ✓✓

1.7 B ✓✓

1.8 C ✓✓

1.9 A ✓✓

1.10 A ✓✓

[20]

QUESTION 2 CHEMICAL BONDING

- 2.1.1 A measure of the tendency of an atom to attract✓ a bonding pair of electrons✓. (2)
- 2.1.2 (a) Pure✓ covalent✓ (2)
(b) Polar✓ covalent ✓ (2)
- 2.2 $\begin{array}{c} \text{H} \times \ddot{\text{P}} \times \text{H} \\ \times \\ \text{H} \end{array}$ ✓✓no. of valence electrons for element (3)
✓bonding pairs of electrons
- 2.3 A weak force of attraction✓ between molecules, or between atoms of noble gases✓. (2)
- 2.4.1 London forces/induced dipole – induced dipole forces/dispersion forces✓. (1)
- 2.4.2 Hydrogen bonds✓. (1)
- 2.5.1 Metallic bonding✓ (1)
- 2.5.2 Due to the electrons drifting in a sea of delocalised electrons (loosely held)✓, They can easily carry the current through the copper✓. (2)

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QUESTION 3 ENERGY CHANGE AND REACTION RATES

- 3.1 5 minutes.✓ (1)
- 3.2 rate decreased✓
as reactants are used up there are fewer reactants **per dm³**✓
therefore fewer collisions and fewer **effective** collisions **per second**✓ (3)
- 3.3 Ave rate = $\frac{\Delta V}{\Delta t}$ ✓ = $\frac{37-0}{(5 \times 60)-0}$ ✓ = 0,12 cm³.s⁻¹✓ (4)
- 3.4 2 – D✓: more tablets ∴ more product and steeper gradient.✓ (2)
3 – C✓: higher concentration HCl ∴ faster reaction rate.✓ (2)
4 – B✓: lower temperature ∴ slower reaction rate.✓ (2)
[14]

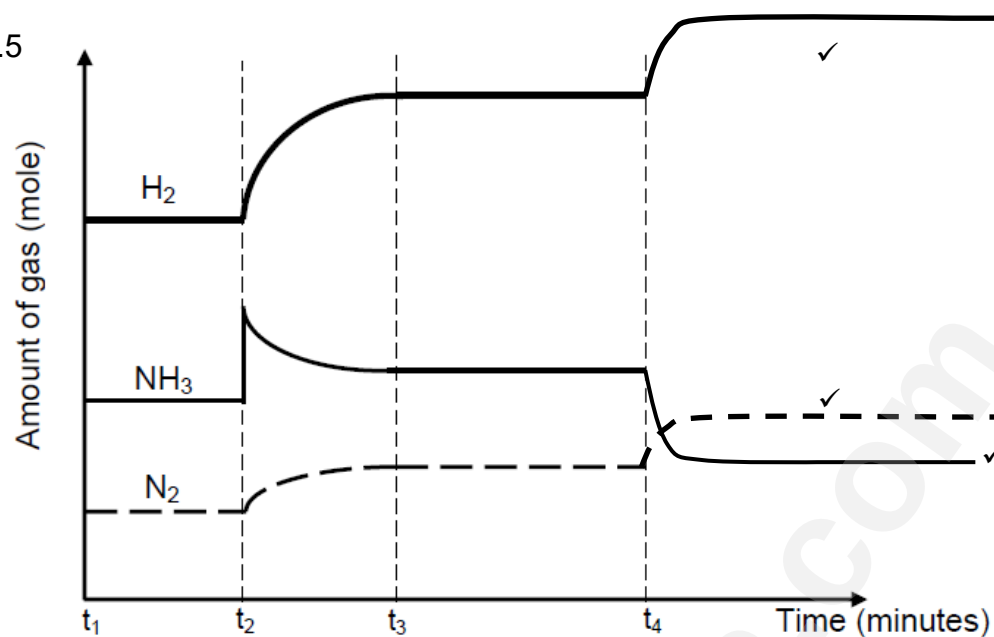
QUESTION 4 CHEMICAL EQUILIBRIUM

- 4.1.1 increase✓ 4.1.2 decrease✓ 4.1.3 decrease✓ 4.1.4 increase✓
4.1.5 increase✓ 4.1.6 the same.✓ (6)
- 4.2 When an external stress is applied to a closed system in chemical equilibrium✓, the equilibrium point will shift✓ in such a way as to counteract the stress✓. (3)
- 4.3.1 $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$

I	0,25	0,2	0
C	0,2	0,1	0,2
E	0,05	0,1	0,2
c = n/v	0,025	0,05	0,1

Number of moles of SO₂ at equilibrium = 0,25 – 0,2✓ = 0,05 mol✓ (2)
- 4.3.2 (a) [SO₂] = 0,05 ÷ 2✓ = 0,025 mol.dm⁻³✓
[O₂] = 0,1 ÷ 2 = 0,05 mol.dm⁻³✓ (3)
- 4.3.2 (b) $K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]}$ ✓ = $\frac{(0,1)^2}{(0,025)^2(0,05)}$ ✓ = 320✓ (3)
- 4.4.1 When the rate of the forward reaction equals✓ the rate of the reverse reaction.✓ (2)
- 4.4.2 t₁ to t₂:✓ Mol of gases remained constant.✓ (Not accepting zero gradient) (2)
- 4.4.3 [NH₃] increased / NH₃ added to equilibrium mixture.✓ (1)
- 4.4.4 Stress: increase in [NH₃]
Response: Favour reaction that will decrease [NH₃]✓
Favour reverse reaction✓ which produces more reactants
[H₂] and [N₂] increases✓ (3)

4.4.5



(3)

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QUESTION 5 ACIDS AND BASES

5.1.1 The extent to which the acid ionises✓ in an aqueous solution✓. (2)

5.1.2 Benzoic acid is a weak acid✓
It has a low K_a value ($K_a < 1$)✓ This means that when it dissolves in water and equilibrium is established, there are not a lot of ions in the solution compared to the amount of unionised acid✓ (3)

5.1.3 poor✓ (1)

5.1.4 **Stress:** water is added✓
Response: Forward reaction is favoured✓
Reason: Forward reaction uses up the excess water thereby relieving the stress on the system✓ (3)

5.2.1 $H_2O_{(l)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + OH^-_{(aq)}$ ✓ ✓balancing ✓indicators (4)

5.2.2 Ampholyte – substance that can act as both ✓an acid or a base✓ (proton acceptor or proton donor) (2)

5.2.3 Endothermic✓when temperature increases K_w increases✓. This indicates that the forward reaction is favoured✓. According to LCP when T increases the endothermic reaction is favoured because it absorbs the excess heat energy thereby counteracting the stress.✓ (4)

$$\begin{aligned}
 5.3.1 \quad n &= c \cdot V \checkmark_{eq} \\
 &= 0,5 \times 0,1 \checkmark \\
 &= 0,05 \text{ mol HCl} \\
 n_{NaOH} &= 0,3 \times 0,06 \checkmark = 0,018 \text{ mol NaOH}
 \end{aligned}$$

Mol ratio $\rightarrow$ 1 NaOH : 1 HCl
 $\therefore$ 0,018 mol HCl was left over
 $\therefore$ 0,05 – 0,018 = 0,032 mol HCl reacted with CaCO_3 in the pearl $\checkmark_{method}$

$$\begin{aligned}
 \text{Mol ratio} &\rightarrow 1 \text{CaCO}_3 : 2 \text{HCl} \\
 0,016 \checkmark &: 0,032 \\
 m &= n \times M \checkmark_{eq} = 0,016 \times 100 \checkmark = 1,6 \text{ g of CaCO}_3 \text{ in the pearl} \checkmark
 \end{aligned}$$

(8)

$$5.3.2 \quad n = \frac{m}{M} = \frac{1,6}{100} \checkmark = 0,016 \text{ mol} \checkmark$$

Mole ratio $\rightarrow$ $\text{CaCO}_3 : \text{CO}_2$
 1:1

$\therefore$ 0,016 mol of CO_2 were evolved $\checkmark$

$$V = n \times V_m = 0,016 \times 22,4 \checkmark = 0,36 \text{ dm}^3 \checkmark (0,03584 \text{ dm}^3) \quad (5)$$

5.3.3 By repeating the test at least 3 times $\checkmark$ to obtain an average result $\checkmark$ (2)

5.3.4 Burette $\checkmark$ (1)

5.3.5 Endpoint $\checkmark$ (1)

5.4.1 A substance in which the hydrogen of an acid $\checkmark$ has been replaced by a cation $\checkmark$ (2)

5.4.2 $\text{NaOH} \checkmark + \text{H}_2\text{CO}_3 \checkmark \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} \checkmark$ (3)

5.4.3 $\text{pH} > 7 \checkmark$ (1)

5.4.4 $\text{Na}_2\text{CO}_3 \rightarrow \text{Na}^+ + \text{CO}_3^{2-}$
 Na^+ comes from strong base NaOH and therefore does not undergo hydrolysis ✓
 CO_3^{2-} comes from weak acid H_2CO_3 and therefore will undergo hydrolysis ✓
 $\text{CO}_3^{2-} + \text{H}_2\text{O} \rightarrow \text{HCO}_3^- + \text{OH}^-$ ✓ equation
Excess OH^- ions increases pH ✓ (4)

OR

$\text{Na}_2\text{CO}_3 \rightarrow \text{Na}^+ + \text{CO}_3^{2-}$ ✓ equation
 $\text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^-$
 Na^+ comes from strong base NaOH and therefore does not undergo hydrolysis ✓
 CO_3^{2-} comes from weak acid H_2CO_3 and therefore will undergo hydrolysis and reassociate with H^+ ions. ✓
This causes the equilibrium for water to shift to the right and more OH^- ions to be produced which increases the pH of the solution ✓ (4)

[46]

QUESTION 6 GALVANIC CELLS

6.1 Tin (Sn) electrode✓ – mass increases✓ and thus Sn^{2+} ions gain electrons to be reduced to Sn. ✓ (3)

6.2 The electrode where oxidation takes place✓ (1)

6.3 Metal X✓ to Tin electrode✓ (right to left) (2)

6.4 $E^\ominus_{\text{cell}} = E^\ominus_{\text{cathode}} - E^\ominus_{\text{anode}}✓$

$$0,6 = -0,14 - X✓$$

$$X = -0,14 - 0,6$$

$$X = -0,74\text{V}✓ \quad (3)$$

6.5 Cr✓ (1)

6.6 $3 \text{Sn}^{2+} + 2 \text{Cr}✓ \rightarrow 3 \text{Sn} + 2 \text{Cr}^{3+}✓$ (2)

6.7 $\text{Cr}_{(\text{s})} \mid \text{Cr}^{3+}_{(\text{aq})} (1 \text{mol} \cdot \text{dm}^{-3})✓ \parallel \text{Sn}^{2+}_{(\text{aq})} (1 \text{mol} \cdot \text{dm}^{-3}) \mid \text{Sn}_{(\text{s})} ✓$ at 25°C ✓ (3)

6.8 1) To complete the circuit.✓ **OR**

2) To maintain electrical neutrality of the two half cells✓ **OR**

3) To allow the electrolytes in the anode and cathode to be physically separate but electrically connected. ✓ (1)

6.9.1 no effect✓ (1)

6.9.2 increase✓. (1)

6.9.3 decrease✓. (1)

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QUESTION 7 ELECTROLYTIC CELLS

7.1 Electroplating✓ (1)

7.2 7.2.1 A✓ (1)

7.2.2 B✓ (1)

7.3 7.3.1 REMAINS THE SAME✓
 Cu^{2+} ions give the solution its blue colour✓
 As quickly as Cu^{2+} ions are reduced at the cathode/bracelet, Cu atoms are oxidised at the anode to produce more Cu^{2+} ions✓, thereby keeping the $[\text{Cu}^{2+}]$ constant (3)

7.3.2 $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ ✓✓ (2)

7.4

7.4.1 The aluminium electrode will break down/corrode✓ over time (1)

7.4.2 Hydrogen✓ (1)

7.4.3 H_2O is a stronger oxidising agent than Al^{3+} ✓ so at the -ve electrode, H_2O will be preferentially reduced over Al^{3+} to form H_2 ✓
 $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$ ✓✓ (4)

[14]

QUESTION 8 CHLOR-ALKALI PROCESS

8.1 P: H_2 ✓ Q: Cl_2 ✓ (2)

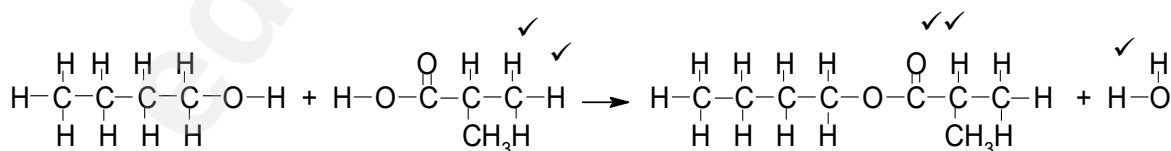
8.2 $E^\circ_{\text{cell}} = E^\circ_{\text{c}} - E^\circ_{\text{a}} = -0.83\text{V} - 1.36\text{V} = -2.19\text{V} < 0$ (3)
[5]

QUESTION 9 ORGANIC CHEMISTRY

- 9.1.1 Prop[✓]ene.[✓] (2)
- 9.1.2 Unsaturated.[✓] (1)
- 9.2.1 hydroxyl.[✓] (1)
- 9.2.2 Molecule with the same molecular formula [✓]but different structural formula[✓]. (2)
- 9.2.3 D[✓] (1)
- 9.2.4 B/C[✓] (1)
- 9.3 3[✓]-methyl[✓]hept-1-ene[✓]. (3)
- 9.4.1 A series of compounds with the same functional group and similar chemical properties[✓], in which each successive member differs by -CH₂-[✓]. (2)
- 9.4.2 Esters[✓] (1)
- 9.5.1 As the number of carbon atoms increases, so does the electron density and/or interacting/contact surface area of the molecule[✓].
This creates larger temporary dipoles[✓] and stronger London forces[✓].
Therefore more energy required to overcome these forces[✓] (4)
- 9.5.2 Alcohols have higher boiling points than alkanes because alcohols have stronger IMFs[✓] (hydrogen bonds[✓]) than corresponding alkanes (London Forces[✓])
Therefore more energy is required[✓] to overcome the IMFs in alcohols and their boiling points are higher. (4)

[22]**QUESTION 10**

- 10.1 Halogenation/Substitution[✓] (1)
- 10.2 Elimination[✓] (1)
- 10.3 1,2[✓]-dibromo[✓]butane[✓] (3)
- 10.4.1 (5)



- 10.4.2 catalyst[✓] and dehydrating agent[✓] (2)
- 10.4.3 to prevent open flame from igniting alcohol vapours[✓]
to heat reaction mixture slowly so that reactants can react before vaporising[✓] (2)
- 10.5 C₄H₁₀O + 6O₂ → 4CO₂ + 5H₂O ^{✓✓}balancing only (mark negatively) (2)

[16]