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Question 1

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

(10 x 2) [20]

Question 2

- 2.1.1 B
- 2.1.2 C
- 2.1.3 D or G
- 2.1.4 G
- 2.1.5 E
- 2.1.6 J
- 2.1.7 B or F or H or I

(7)

2.2.1 Non-polar or Pure✓ covalent bonds ✓

(2)

2.2.2 Halogens have weak London forces.✓

As the number of electrons increase✓ the size of temporary dipoles increase.✓

More energy required to overcome forces✓ of attraction and hence a higher boiling point

OR

Halogens have weak London forces.✓

The larger molecules (not more mass)✓ have more points of contact for temporary dipoles to form✓.

More energy required to overcome MORE (concept of cumulative forces must be stated for this final mark) forces✓ of attraction and hence a higher boiling point

(4)

[13]

Question 3

3.1 $n_{HCl} = cV \checkmark = 1 \times 0,05 \checkmark (\text{both subs}) = 0,05 \text{ mol} \checkmark$

$$n_{CaCO_3} = \frac{m}{M} \checkmark = \frac{20}{100} \checkmark = 0,2 \text{ mol} \checkmark$$

$n_{HCl} : n_{CaCO_3}$ is 2:1 $\therefore 0,05 \text{ mol}$ only uses $0,025 \text{ mol } CaCO_3 < n_{CaCO_3} \text{ present} \checkmark$ ratio concept
 $\therefore CaCO_3$ is in excess and HCl is limiting (7)

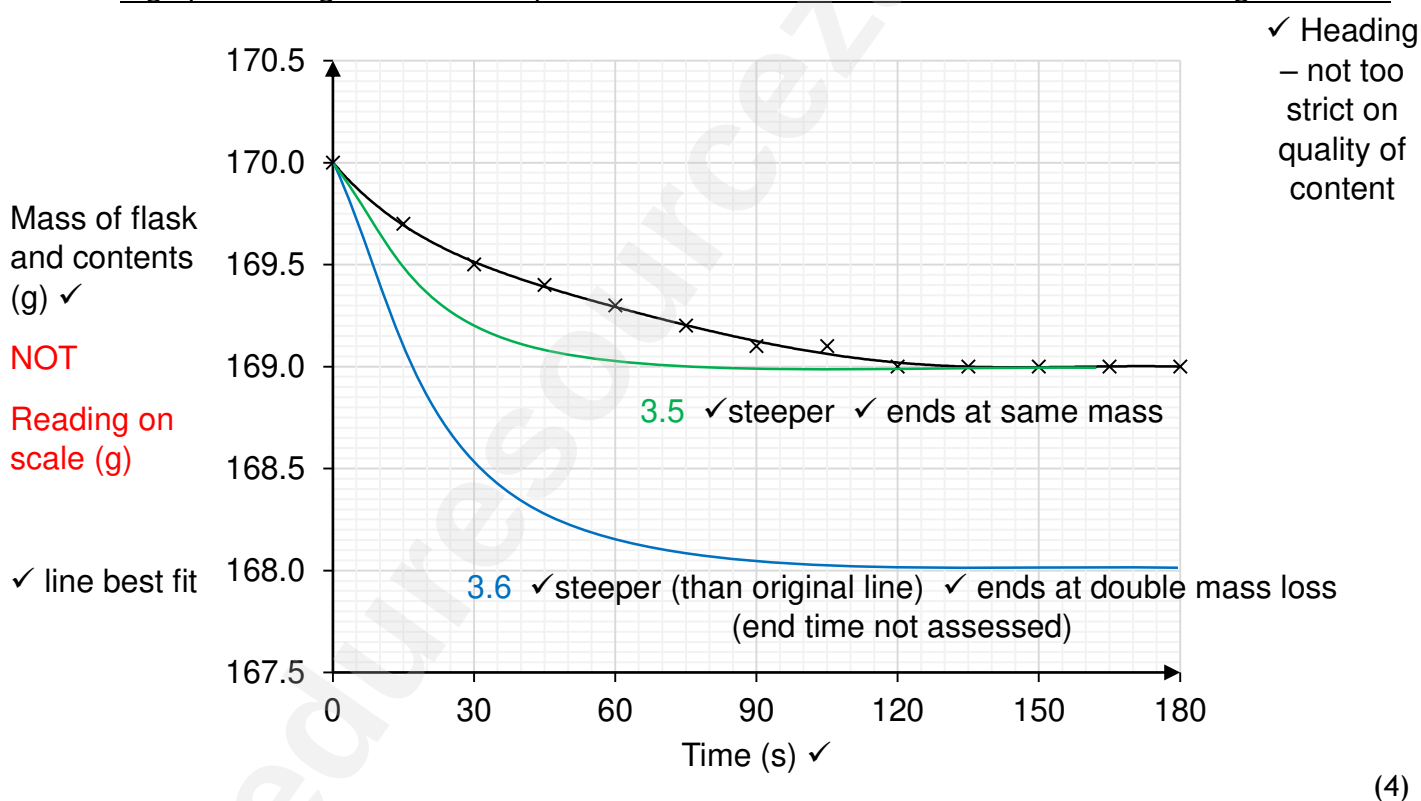
3.2 $n_{CO_2} = \frac{m}{M} = \frac{(170-169) \checkmark}{44 \checkmark} = 0,023 \text{ mol}$

$n_{HCl} : n_{CO_2}$ is 2:1 $\therefore 0,05 \text{ mol}$ should produce $0,025 \text{ mol } CO_2 \checkmark$ (use of ratio from HCl only)

$$\% \text{ yield} = \frac{\text{actual moles produced}}{\text{theoretical moles possible}} \times 100 = \frac{0,023}{0,025} \checkmark \checkmark \times 100 = 90,9\% \checkmark \quad (6)$$

OR use mole ratio (as above $\checkmark$) then calculate grams of CO_2 that should be produced from $0,025 \text{ mol}$ ($m = nM = (0,025 \checkmark)(44 \checkmark) = 1,1 \text{ g}$) and then calculate purity based on 1 g actually released: $1 \checkmark / 1,1 \checkmark \times 100 = 90,9\% \checkmark$ (6)

3.3 A graph showing the relationship between mass of flask and contents and time during a reaction



3.4 $av \text{ rate} = \frac{\Delta m}{\Delta t} = \frac{(169,3-170,0) \text{ must be ON their line} \checkmark \checkmark}{60} \checkmark \checkmark = -1,17 \times 10^{-2} \checkmark g \cdot s^{-1} \quad (3)$

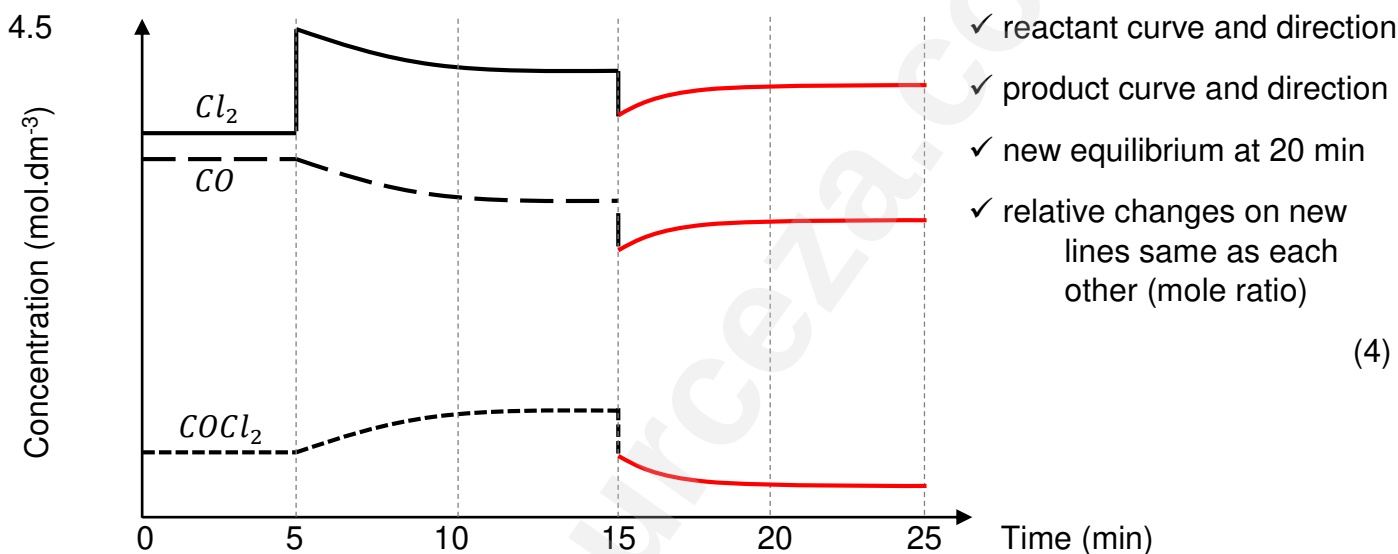
Av rate is negative because it is loss of mass (the order of subs and – or + is not critical here (not penalised)

3.5 & 3.6 See above (2) & (2)

3.7 The rate of the reaction decreases ✓
 There is a decrease in the surface area ✓ of the reactant and thus fewer reactant particles are exposed ✓ to each other
 Thus there are fewer collisions per unit time ✓ (and thus fewer effective collisions per unit time.) (4)

Question 4

- 4.1 Increase in concentration of chlorine or chlorine was added ✓ (1)
- 4.2 $\uparrow[Cl_2]$ – according to Le Châtelier's Principle the system will adjust to counteract the stress and thus decrease the concentration or number of moles of Cl_2 . ✓
Thus the reverse reaction is favoured ✓ (and the equilibrium shifts to the left)
resulting in a decrease in the concentrations of Cl_2 and CO and an increase in the concentration of $COCl_2$ ✓ (3)
- 4.3 Concentration is the amount of solute ✓ per unit volume ✓ (2)
- 4.4 At 15 minutes the concentrations of all gaseous substances dropped ✓ indicating that the volume of the container had increased ✓. Thus the disturbance is a decrease in pressure. ✓ (3)



- 4.6 B ✓✓ (2)
- 4.7.1 $K_c = \frac{[CO][Cl_2]}{[COCl_2]}$ ✓ (this mark cannot be implied by a correct answer below. It must be stated)
 $K_c = \frac{(0,40)(0,52)}{(0,009)}$ ✓✓ subs $(-1 []) = 23.1$ ✓ (4)
- 4.7.2 The K_c for the reaction has decreased thus there are more reactants in the new equilibrium (or less products) ✓
Thus the reverse reaction must have been favoured ✓
The reverse reaction is exothermic ✓
Thus the stress was a decrease ✓ in temperature ✓ (5)

Question 5

- 5.1.1 pH✓ (1)
- 5.1.2 The point where an acid and a base have reacted✓ so that neither one is in excess✓. (2)
- 5.1.3 The equivalence point is reached at a pH of 9 (accept 8,5-9,5) ✓ when 14,5 cm³ or ml ✓ of base✓ has been added to the conical flask. (3)
- 5.1.4 $\text{HX} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{X}^-$ ✓✓product ions (double or single arrow accepted here) (2)
- 5.1.5 (a) $K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$ ✓
 $[\text{H}_3\text{O}^+](1 \times 10^{-11}) = 1 \times 10^{-14}$ ✓subs
 $[\text{H}_3\text{O}^+] = 1 \times 10^{-3} \text{ mol. dm}^{-3}$
 $K_a = \frac{[\text{H}_3\text{O}^+][\text{X}^-]}{[\text{HX}]} = \frac{(1 \times 10^{-3})(1 \times 10^{-3})}{0.17} = 5,9 \times 10^{-6}$ ✓ (8)
- 5.1.5 (b) Weak ✓acid as K_a value is very small ✓ (2)
- 5.1.5 (c) Any single valency non-metal element: F, Br, I (not Cl) (accept name/formula) or any single negative charge polyatomic ion other than nitrate. (1)
- 5.2.1 Hydrolysis of a salt: a reaction of an ion (from a salt) with water✓ (1)
- 5.2.2 sodium hydroxide ✓ carbonic acid ✓ (2)
- 5.2.3 Basic ✓ (1)
- 5.2.4 The hydrochloric acid ionises putting H_3O^+ ions into solution. H_3O^+ ions react with the OH^- ions in the buffer equilibrium reducing the $[\text{OH}^-]$ ✓ thus the forward reaction is favoured/shift right✓ increasing $[\text{OH}^-]$ ✓ and counteracting the drop in pH caused by the addition of the acid✓ (concept) keeping the pH of the solution stable. (4)

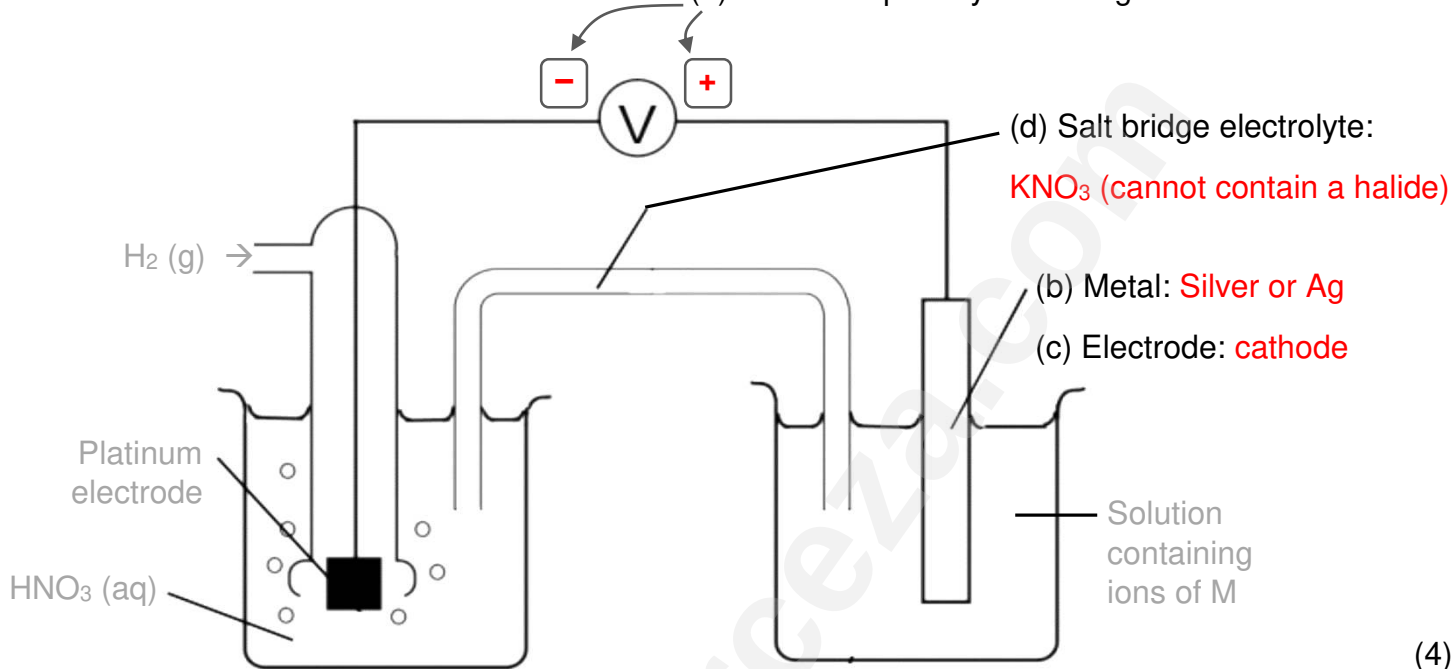
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Question 6

6.1.1 An anode is the electrode where oxidation takes place. ✓ (1)

6.1.2 Aqueous solutions of ions: $1 \text{ mol} \cdot \text{dm}^{-3}$ ✓
 Gas pressure: 1 atm ✓
 Temperature: 25°C ✓ (3)

6.1.3 (a) Voltmeter polarity: insert signs in the boxes shown



6.1.4 $\text{Pt}(\text{s}) \mid \text{H}_2(\text{g}) \mid \text{H}^+(\text{aq}) \parallel$ ✓ format with vertical lines between phases
 ✓ order of substances ✓ identity of substances (-1 phase error, -1 if NOT a double line for salt bridge) (3)

6.1.5 It allows anions (or identify negative ions from this cell) to flow to the anode (or to SHE half cell) ✓ and cations (or identify positive ions from this cell) to flow to the cathode (or to Ag half cell). (2)

6.1.6 The reading decreases ✓
 An increase in the $[\text{H}^+]$ (a product) ✓ favours the reverse reaction ✓ and decreases the emf. (3)

6.2.1 Oxidation half reaction: $\text{Fe} \rightarrow \text{Fe}^{3+} + 3\text{e}^-$ ✓✓ (-1 for use of $\rightleftharpoons$)

Reduction half reaction: $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$ ✓✓ (max 2 if $\frac{1}{2}$ rxns correct but swapped)

$$\begin{aligned} E^\ominus_{\text{cell}} &= E^\ominus_{\text{cat}} - E^\ominus_{\text{an}} \\ &= (+0,80) - (-0,04) \quad \checkmark \checkmark \text{subs} \\ &= +0,84 \text{ V (no mark: proven)} \end{aligned} \quad (6)$$

6.2.2 $\text{Fe} + 3 \text{Ag}^+ \rightarrow \text{Fe}^{3+} + 3 \text{Ag}$ ✓sum of halves coe ✓balanced coe (2)

[24]

Question 7

- 7.1.1 Anode✓ (1)
- 7.1.2 Increase the concentration of the chloride ions ✓
 The electrode potentials of the two half reactions that produce chlorine and oxygen are very similar (+1,36V and +1,23V) ✓ (values NOT required)
 H₂O is inherently more reactive than chloride ions/H₂O will normally oxidise in preference to the chloride ions/H₂O is a stronger reducing agent than chloride ions. ✓ (inherent reactivity) but the increased concentration of the chloride ions allows the formation of chlorine gas to happen at a greater rate✓ than the H₂O half reaction, hence chlorine gas predominates (4)
- 7.1.3 $n_{Cu} : n_{e^-}$ is 1:2 ✓ ∴ 0,011 mol: 0,022 mol electrons
 $Q = nF$ $Q = 0,022(96500)$ ✓ = 2123 C
 $I = \frac{Q}{t}$ ✓ = $\frac{2123}{600}$ ✓ = 3,54 A✓ (6)
- 7.1.4 $n_{Cu} : n_{Cl_2}$ is 1:1 ✓ ∴ 0,011 mol: 0,011 mol
 $V = nV_M$ ✓ = 0,011(22,4)✓ = 0,25 dm³✓ (4)
- 7.2.1 It becomes smaller or corrodes✓ (1)
- 7.2.2 hydrogen✓ gas (1)
- 7.2.3 H₂O is a stronger oxidising agent than the Al³⁺ ions✓,
 thus water will be reduced in preference to the Al³⁺ ions✓
 $2H_2O + 2e^- \rightarrow H_2(g) + 2OH^-$ ✓ (3)
- [20]

Question 8

- 8.1 A functional group as an atom or a group of atoms✓ that form the centre of chemical activity in the molecule✓ (2)
- 8.2 $\begin{array}{c} O \\ || \\ -C- \end{array} - OH$ ✓ double bond to O ✓ -OH or -O-H (2)
- 8.3 an unsaturated compound is a compound in which there is at least one double and/or triple bond✓ between carbon atoms✓ (2)
- 8.4 Alkanes ✓ (1)
- 8.5 Esters ✓ (1)
- 8.6.1 ✓butan-1-ol✓ (or 1-butanol) (but-1-ol = max 1 & butanol = 1 mark)
 ethanoic acid ✓ (if butanoic acid and ethanol = max 1/3) (3)
- 8.6.2 Heat indirectly using a water bath ✓ (concept of indirect)
 Because reactants and products are highly flammable✓ (2)
- 8.6.3 presence of a concentrated✓ acid✓ catalyst (2)
- 8.6.4 water ✓ (1)

Question 9

- 9.1 General: Elimination ✓ Specific: (thermal) cracking ✓ (2)
- 9.2 $2 C_6H_{14} + 19 O_2 \rightarrow 12 CO_2 + 14H_2O$ ✓r ✓p ✓b (3)
- 9.3.1 Structural isomers are compounds (-1 for elements or atoms) having the same molecular formula ✓ but different structural formulae ✓ (2)
- 9.3.2 Chain ✓ isomerism (1)
- 9.3.3 2-methylpentane / 3-methylpentane / 2,3-dimethylbutane
✓number and side chain ✓main name (-1 space or dash errors) (2)
- 9.4 propene ✓ (1)
- 9.5.1 hydrohalogenation ✓ (1)
- 9.5.2 Absence of water ✓ (1)
- 9.6.1 Substitution ✓ (1)
- 9.6.2
$$\begin{array}{ccccccc} & H & & OH & & H & \\ & | & & | & & | & \\ H & - C & - & C & - & C & - H \\ & | & & | & & | & \\ & H & & H & & H & \end{array}$$
 ✓ -OH group
✓ position on middle C
✓ rest of molecule correct (3)
- 9.6.3 (iv) NaOH ✓ or KOH (or names)
(v) NaCl ✓ or KCl – linked to (iv) (or names) (2)
- 9.6.4 dilute ✓ NaOH (alkali) solution and heat ✓ (under reflux) (2)
- 9.7.1 $L \rightarrow M \rightarrow N$ ✓✓correct (✓ any two in correct order) (2)
- 9.7.2 L: London forces ✓
M: dipole-dipole forces ✓
N: hydrogen bonds ✓ (3)
- 9.7.3 N has the strongest ✓ of the intermolecular forces thus more energy is required to overcome the forces ✓ of attraction for boiling to occur. (2)

[28]

TOTAL MARKS: 200