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QUESTION 1

TOTAL: /20

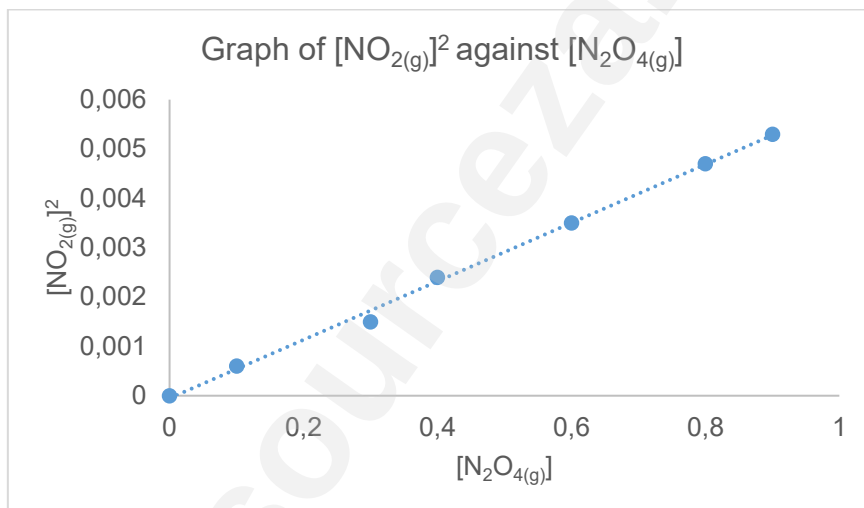
- | | | | |
|----------|----------|----------|-----------|
| 1.1) C✓✓ | 1.4) A✓✓ | 1.7) B✓✓ | 1.10) D✓✓ |
| 1.2) B✓✓ | 1.5) D✓✓ | 1.8) A✓✓ | |
| 1.3) B✓✓ | 1.6) C✓✓ | 1.9) B✓✓ | |

QUESTION 2

TOTAL: /18

- 2.1) Heading.✓
 Labelled axes.✓✓
 Scale.✓
 Plotted points.✓
 Line of best fit.✓✓

(7)



- 2.2) Concentration of N_2O_2 .✓✓ (1)
- 2.3) Pick two points on line of best fit.✓
 $m = \frac{\Delta y}{\Delta x} \checkmark \approx 0,0057 - 0,0062 \checkmark$ (3)
- 2.4) K_c ✓ (1)
- 2.5) Draw a line starting at the origin✓ with a steeper gradient.✓ (2)
- 2.6) The forward reaction is endothermic✓, therefore if the temperature is raised, the reaction will favour the endothermic reaction✓ resulting in more NO_2 and less N_2O_4 causing K_c to increase.✓ (3)

QUESTION 3**TOTAL: /25**

3.1) When an external stress is applied to a system in dynamic equilibrium, the equilibrium point will change in such a way as to counteract the stress.✓✓ (2)

3.2) An increase in concentration of CO_2 in equilibrium 1 will favour the forward reaction✓ resulting in more H_2CO_3 being produced.✓ The increase H_2CO_3 would result in the forward reaction of equilibrium 2 to be favoured✓ resulting in an increase in H^+ ions which would decrease the pH.✓ (4)

3.3) K_{a2} for equilibrium 2 is large suggesting that the equilibrium favours the forward reaction✓ thus H_2CO_3 will easily break up into HCO_3^- ions.✓ K_{a3} for equilibrium 3 is small suggesting that the equilibrium favours the reverse reaction✓ thus HCO_3^- will not break down into the CO_3^{2-} ion hence it is the most abundant.✓ (4)

3.4.1) $K_{a2} = \frac{[\text{HCO}_3^-][\text{H}^+]}{[\text{H}_2\text{CO}_3]}$ ✓ (3)

3.4.2)

	H_2CO_3	H^+	HCO_3^-
Initial	x	0	0
Change	-0,75✓	+0,75	+0,75✓
Equilibrium	$x - 0,75$ ✓	0,75✓	0,75

$$K_{a1} = \frac{[\text{HCO}_3^-][\text{H}^+]}{[\text{H}_2\text{CO}_3]}$$

$$5.0 \times 10^{-1} = \frac{[0,75][0,75]}{[x - 0,75]} \checkmark$$

$$x = 1,875 \text{ mol} \checkmark$$

(6)

3.5.1) The increase in H^+ ions causes the equilibrium 3 to shift and favour the reverse reaction, hence there is a decrease in the CO_3^{2-} ion.✓ The above equilibrium will then favour the forward reaction✓ to produce more CO_3^{2-} ions resulting in CaCO_3 dissolving.✓ (3)

- 3.5.2) Yes.✓ The forward reaction is exothermic therefore the reverse endothermic reaction will be favoured to lower the temperature✓ and would produce more CaCO_3 .✓ (3)

QUESTION 4

TOTAL: /24

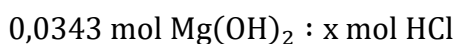
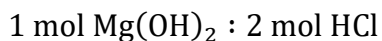
- 4.1.1) Weak force of attraction✓ between molecules, ions or atoms of a noble gas.✓ (2)
- 4.1.2) The ability of an atom to attract the bonded pair of electrons in a covalent bond.✓✓ (2)
- 4.2) Ammonia, NH_3 (or sulphur dioxide, SO_2).✓ Ammonia is a polar molecule that has intermolecular forces (hydrogen bonds or dipole-dipole)✓ that are similar in strength to water.✓ (3)
- 4.3) Sulfur dioxide is a polar molecule that contains dipole-dipole interactions between molecules✓ while water has hydrogen bonds.✓ The hydrogen bonds are stronger than dipole-dipole interactions✓ therefore more energy is required to break the hydrogen bonds than dipole-dipole interactions.✓ (4)
- 4.4.1) Covalent bond.✓✓ (2)
- 4.4.2) Ammonium chloride is an ionic compound. The water molecules form ion-dipoles✓ around the individual cations and anions releasing enough energy to break✓ the electrostatic attraction forces between the cations and anions✓ and eventually surrounding the ions with ion-dipoles.✓ (Please accept a like dissolves in like explanation here as well.) (4)
- 4.4.3) $\text{NH}_4\text{Cl} \rightarrow \text{NH}_4^+ + \text{Cl}^-$ ✓✓ (2)
- 4.4.4) Reaction of an ion from a salt with water.✓✓ (2)
- 4.5.5) $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+$
The ammonium ion is a very strong acid and will readily react with water to form H_3O^+ ions.✓ The chloride ion is a weak base and will hardly react with water. This results in an increase in OH^- ions✓ and an increase in pH✓ (3)

QUESTION 5**TOTAL: /30**

5.1.1) Measure of the extent of a reaction, generally measured by comparing the amount of product against the amount of product that is possible. ✓✓ (2)

$$5.1.2) n_{\text{Mg(OH)}_2} = m/M_r \checkmark = 2,0/58,3 \checkmark = 0,0343 \text{ mol} \checkmark$$

$$n_{\text{HCl}} = CV = (25 \times 10^{-3})(1,75) = 0,04375 \text{ mol} \checkmark$$



$$x = 0,0686 \text{ mol}$$

∴ HCl is the limiting reagent ✓ (5)



$$x = 0,0219 \text{ mol} \checkmark$$

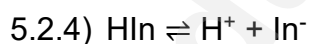
$$m_{\text{MgCl}_2} = (0,75)nM_r \checkmark = (0,75)(0,0219)(95,3) \checkmark = 1,57 \text{ g} \checkmark (4)$$

5.2.1) Magnesium hydroxide dissociates and produces OH^- ions that are proton acceptors. ✓✓ (2)

5.2.2) A solution of known concentration. ✓✓ (2)

$$5.2.3) n_{\text{Mg(OH)}_2} = CV \checkmark = (250 \times 10^{-3})(0,25) \checkmark = 0,0625 \text{ mol} \checkmark$$

$$m_{\text{Mg(OH)}_2} = nM_r = (0,0625)(58,3) \checkmark = 3,64 \text{ g} \checkmark (5)$$



The colour change is based on the following equilibrium. If H^+ ions are in excess the equilibrium favours the reverse reaction resulting in a red colour. ✓

If OH^- ions are in excess, they react with the H^+ ions decreasing their concentration favouring the forward reaction resulting in a yellow solution. ✓

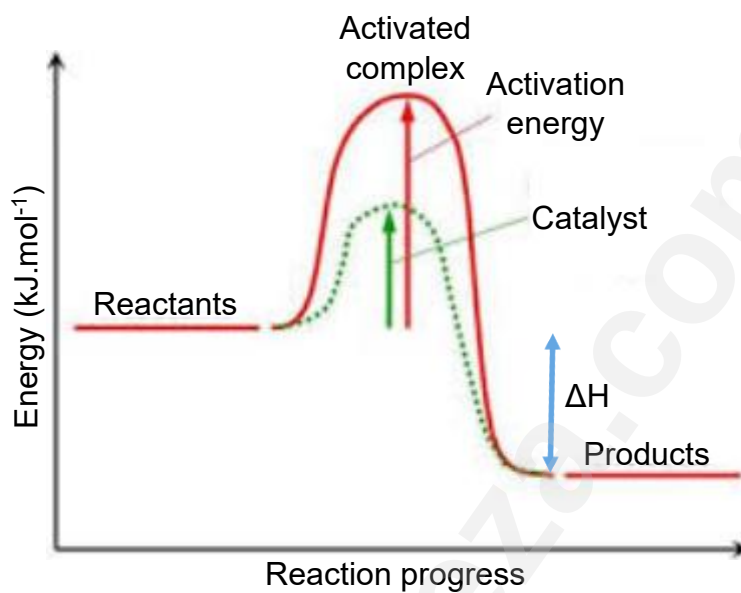
When the H^+ and OH^- ions are equal, there is perfect equilibrium and an orange colour persists. ✓ (3)

5.3.1) Axes.✓

Labels.✓✓✓

Shape.✓

(5)



5.3.2) Dotted line.✓

Lower than the activation energy of the reaction.✓

(2)

QUESTION 6**TOTAL: /26**

- 6.1.1) Substance that accepts electrons.✓✓ (2)
- 6.1.2) The electrode where reduction takes place.✓✓ (2)
- 6.2) $E_{\text{Cell}} = E_{\text{cathode}} - E_{\text{anode}}$ ✓
 $1,51 = 0,77 - E_{\text{anode}}$ ✓
 $E_{\text{anode}} = 0,77 - 1,51 = -0,74 \text{ V}$ ✓
 $\therefore X = \text{Cr}$ ✓ (4)
- 6.3) CrCl_3 ✓✓ (2)
- 6.4.1) The cathode becomes negatively charge✓✓ due to the reduction process.
 The positive ions in the salt bridge migrate into the compartment and
 neutralize the solution.✓ (3)
- 6.4.2) The emf of the cell remains the same.✓✓ (2)
- 6.5) Cathode: $\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$ ✓
 Anode: $\text{Cr} \rightarrow \text{Cr}^{3+} + 3\text{e}^-$ ✓
 Cell: $3\text{Fe}^{3+}_{(\text{aq})} + \text{Cr}_{(\text{s})} \rightarrow \text{Cr}^{3+}_{(\text{aq})} + 3\text{Fe}^{2+}_{(\text{aq})}$ ✓✓ (4)
- 6.6) $\text{Cr}_{(\text{s})}/\text{Cr}^{3+}_{(\text{aq})}(1 \text{ mol.dm}^{-3})//\text{Fe}^{3+}_{(\text{aq})}(1 \text{ mol.dm}^{-3})/\text{Fe}^{2+}_{(\text{aq})}(1 \text{ mol.dm}^{-3}),\text{Pt}$
 (25°C) ✓
 State symbols.✓
 Conditions.✓ (4)
- 6.7) The cell emf would increase.✓ There would be an increase in Fe^{3+} ions which
 would cause the equilibrium to favour the forward (reduction) reaction✓ thus
 causing the cell potential at the cathode to be more positive.✓ (3)

QUESTION 7**TOTAL: /22**

7.1) Electrical energy to chemical energy.✓✓

(2)

7.2.1) $\text{Al}^{3+}_{(l)} + 3\text{e}^- \rightarrow \text{Al}_{(l)}$ ✓✓

(2)

7.2.2) $2\text{O}^{2-}_{(l)} \rightarrow \text{O}_{2(g)} + 4\text{e}^-$ ✓✓

(2)

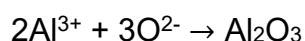
7.3) Cryolite lowers the melting point of the aluminium oxide.✓✓

(2)

7.4) $Q = It = 10 \times 30 \times 60 = 18000 \text{ C}$ ✓

$$n_{\text{e}^-} = 18000 / 96500 = 0,187 \text{ mol}$$
✓

$$n_{\text{Al}} = 0,187 / 3 = 0,062 \text{ mol}$$
✓



$$n_{\text{Al}_2\text{O}_3} = 0,062 / 2 = 0,031 \text{ mol}$$
✓

$$m_{\text{Al}_2\text{O}_3} = nM_r = (0,031)(102) = 3,16 \text{ g}$$
✓ (8)

7.5) The molten alumina means that the electrostatic interactions between the ions are broken resulting in ions that are free to move and a conducting liquid.✓✓

(2)

7.6) Carbon in graphite form is a cheap and relatively good conductor of electricity.✓✓ The carbon electrodes at high temperature react with the oxygen produced at the anode to give carbon dioxide a greenhouse gas.✓✓

(4)

QUESTION 8**TOTAL: /20**

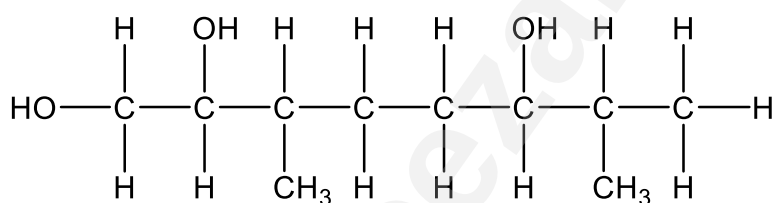
8.1.1) An atom or a group of atoms that form the centre of chemical activity in the molecule.✓✓ (2)

8.1.2) 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 CH₂ unit.✓✓. (2)

8.2) Hydroxyl✓ and double bond✓ (alcohol and alkene). (2)

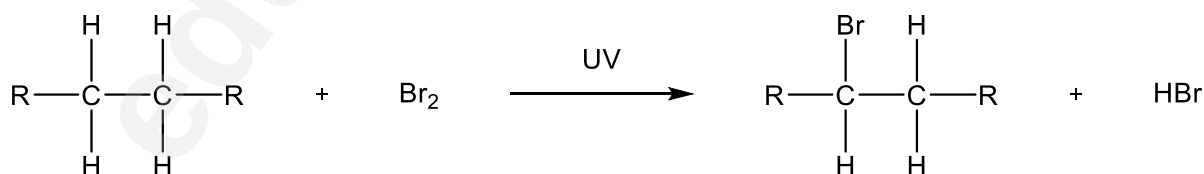
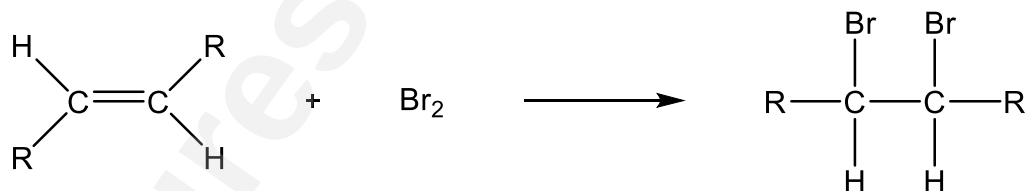
8.3.1) 2,6-dichloro✓-3,7-dimethyl✓ octan✓-1-ol✓ (4)

8.3.2) Substituting chloro-groups with hydroxyl groups.✓✓ (2)



8.3.3) Substitution.✓✓ (2)

8.4) Bromine reacts quite rapidly with alkenes and very slowly with alkanes in the presence of UV light.✓✓
Two reactions.✓✓✓✓ (6)



QUESTION 9**TOTAL: /15**

- 9.1) Butanoic acid✓✓ and propan-1-ol.✓ (3)
- 9.2) The butanoic acid✓ has both dipole-dipole interactions✓ and hydrogen bonding✓ compared only to the hydrogen bonding in the propan-1-ol.✓
Hence more energy is required to break the intermolecular forces in butanoic acid.✓ (5)
- 9.3) It acts as the catalyst✓✓ (2)
- 9.4) Compounds having the same molecular formula but different structural formulae.✓✓ (2)
- 9.5) Heptanoic acid
Longest chain.✓✓
Carboxyl functional group.✓ (3)

