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QUESTION 1

TOTAL: /20

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

QUESTION 2

TOTAL: /20

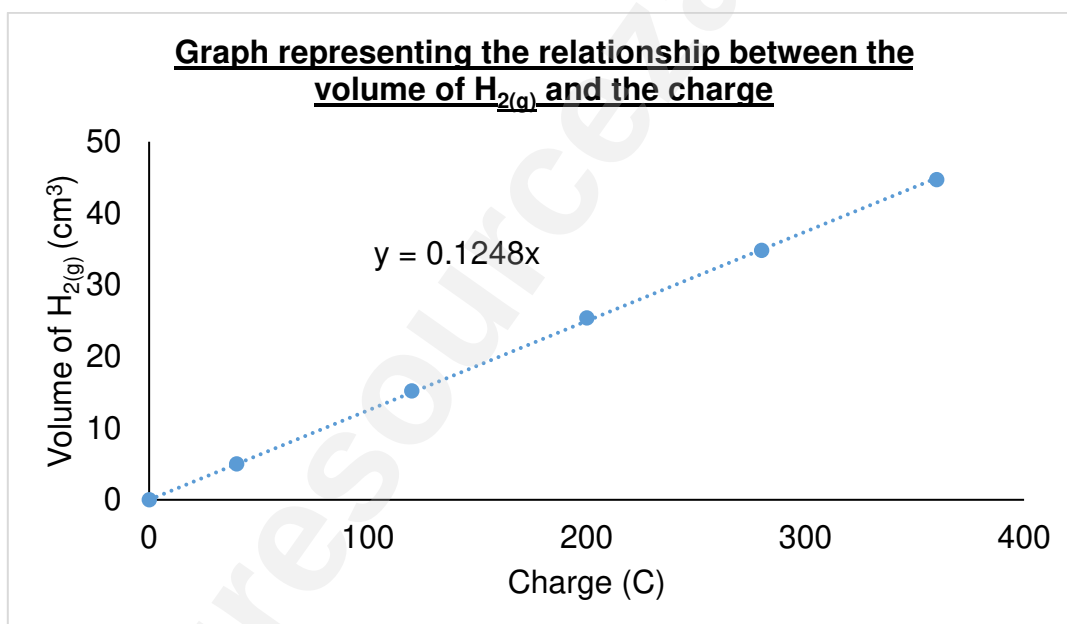
- 2.1) A measure of the tendency of an atom to attract the bonding pair of electrons.✓✓ (all or nothing) (2)
- 2.2) Nitrogen has pure (non-polar) covalent bonds✓, as it has an electronegativity difference between the nitrogen atoms of zero.✓ Methane has polar covalent bonds✓, as it has an electronegativity difference (0,4) between the carbon and hydrogen atoms.✓ (4)
- 2.3) Weak force of attraction between molecules, ions and atoms of a noble gas.✓✓ (all or nothing) (2)
- 2.4) Ammonia.✓ Ammonia is a polar molecule that consists of hydrogen bonds between the molecules.✓ Hydrogen cyanide is a polar molecule that consists of dipole-dipole forces.✓ Hydrogen bonds are stronger than dipole-dipole forces.✓ More energy is required to break hydrogen bonds hence at lower temperatures the forces are more effective (higher boiling point).✓ (5)
- 2.5) The electrons in molecules move freely around the molecule.✓ At a given moment, the electrons will be at one end of the molecule✓ resulting in a temporary dipole (temporary δ^+ and δ^-).✓ This temporary dipole interacts with other temporary dipoles creating a London force.✓ (No marks for diagrams but give credit for diagrams if they help dispel ambiguity and aid written answer) (4)
- 2.6.1) non-polar✓ (1)
- 2.6.2) polar✓ (1)
- 2.6.3) polar✓ (1)

QUESTION 3**TOTAL: /30**

3.1) Electrolytic cell (Hofmann Voltammeter).✓ Electrical energy to chemical (potential) energy.✓ (2)

3.2) $Q = It$ ✓
 $Q = (0,8)(150)$ ✓ = 120 C✓ (3)

3.3) Heading.✓
 Axes labels with units.✓✓
 Scale (at least $\frac{1}{2}$ the area of the graph paper).✓
 Plotting of points.✓
 LOBF passing through the origin.✓✓ (7)



3.4) Burette 1.✓ Reduction has occurred here.✓ (2)

3.5) Yes.✓ Most of the points are on the line of best fit.✓ (2)

3.6) Construction lines.✓
 $m = \frac{\Delta y}{\Delta x} \approx 0,1248 (\pm 0,1)$ ✓ (4)

3.7) $F = \frac{V_M}{m} = \frac{(24000)}{0,1248}$ ✓ = 192307 C per 2 moles of e^- ✓
 $\therefore F = 192307/2 = 96154 \text{ C} \cdot \text{mol}^{-1}$ ✓ (4)

- 3.8) A straight line going through the origin✓ that is steeper than the plotted line.✓ (2)
- 3.9) Any of the answers of inert, good conductor of electricity or good adsorber of gas.✓ (1)
- 3.10) Copper would be preferentially oxidized rather than the water✓ as it is a better reducing agent.✓ The electrode would corrode away.✓ (3)

QUESTION 4**TOTAL: /35**

4.1.1) Only the gas escapes and not the other contents of the flask.✓✓ (2)

4.1.2) Change in concentration per unit time of either reactant or product.✓✓
(all or nothing) (2)

4.1.3) No✓, the graph has not plateaued.✓ (2)

4.1.4) Use of either a gas collection device and the measurement of the volume of gas **or** the use of a colourimeter to measure the intensity of the colour over a period of time.✓✓ (2)4.1.5) average rate = $\Delta \text{mass} / \Delta t$
average rate = $(164,73 - 164,85) / (30 - 10)$ ✓ = $-0,006 \text{ g} \cdot \text{s}^{-1}$ ✓
average rate = $-0,006 / 44$ ✓ = $-1,36 \times 10^{-4} \text{ mol} \cdot \text{s}^{-1}$ ✓ (4)

4.1.6) a) A line with a steeper gradient✓ and a lower end mass.✓ (2)

b) A line with a shallower gradient✓ and higher end mass.✓ (2)

4.1.7) a) $n_{\text{CO}_2} = V / V_M = 0,180 / 22,4$ ✓ = $0,0080 \text{ mol}$ ✓
 $n_{\text{CO}_2} = n_{\text{CuCO}_3} = 0,0080 \text{ mol}$ ✓
 $m_{\text{CuCO}_3} = n M_R = (0,0080)(123,5)$ ✓ = $0,99 \text{ g}$ ✓
 $\% \text{purity} = 0,99 / 1,50 \times 100 = 66\%$ ✓ (6)

b) Amount of solute per unit volume of solution.✓✓ (2)

c) $n_{\text{HCl}} = CV = (0,075)(0,25) = 0,01875 \text{ mol}$ ✓
The amount of HCl left over:
 $n_{\text{HCl}} = 0,01875 - (0,0080 \times 2)$ ✓ = $0,00275 \text{ mol}$ ✓
 $C_{\text{HCl}} = n / V = 0,00275 / 0,075$ ✓ = $0,037 \text{ mol} \cdot \text{dm}^{-3}$ ✓ (5)

- 4.2.1) Increase in (amount) concentration.✓ There are more reactant particles per unit volume.✓ Therefore there are more effective collisions per unit time leading to more collisions with energy greater than the activation energy.✓ (3)
- 4.2.2) Increase in temperature.✓ More reactant particles have kinetic energy greater than the activation energy.✓ Therefore there are more effective collisions per unit time.✓ (3)

QUESTION 5**TOTAL: /15**

5.1) System where energy can enter or exit✓ but matter cannot.✓ (2)

5.2)

Reaction	NH ₃	O ₂	NO	H ₂ O
Initial (mol)	6,00	5,00	3,00	1,00
Change (mol)	-0,40	-0,50	+0,40	+0,60
Eq ^m (mol)	5,60	4,50	3,40✓	1,60
Conc. (mol.dm ⁻³)	2,80✓	2,25✓	1.70	0,80✓

$$K_C = \frac{[\text{NO}]^4 [\text{H}_2\text{O}]^6}{[\text{NH}_3]^4 [\text{O}_2]^5} \checkmark$$

$$K_C = \frac{(1,70)^4 (0,80)^6}{(2,80)^4 (2,25)^5} \checkmark = 6,18 \times 10^{-4} \checkmark \quad (7)$$

5.3) When an external stress (change in pressure, temperature or concentration) is applied to a system in dynamic chemical equilibrium, the equilibrium point will change in such a way as to counteract the stress.✓✓ (2)

5.4) Endothermic.✓ An increase in temperature has resulted in there being more products being produced as shown by the increase in the K_C value.✓ Hence the forward reaction is favoured which needs to absorb energy from the system.✓ (3)

5.5) It will reach equilibrium faster (in a shorter period of time).✓ (1)

QUESTION 6**TOTAL: /20**

6.1.1) A base is a proton acceptor. ✓✓ (all or nothing) (2)

6.1.2) The acid will completely ionize in solution. ✓✓ (2)

6.1.3) $C_{H_3O^+} = 2 \times C_{H_2SO_4} = 2 \times (0,010) \checkmark = 0,020 \text{ mol. dm}^{-3} \checkmark$

$$K_W = [H_3O^+][OH^-]$$

$$[OH^-] = \frac{K_W}{[H_3O^+]} \checkmark = \frac{(1 \times 10^{-14})}{(0,020)} = 5,00 \times 10^{-13} \text{ mol. dm}^{-3} \checkmark \quad (4)$$

6.1.4) The point where an acid and base have reacted so neither is in excess. ✓✓
(all or nothing) (2)

6.1.5) $n_{H_2SO_4} = CV = (25 \times 10^{-3})(0,010) = 2,50 \times 10^{-4} \text{ mol} \checkmark$

$$n_{KOH} = 2 \times n_{H_2SO_4} = 2 \times 2,50 \times 10^{-4} = 5,00 \times 10^{-4} \text{ mol} \checkmark$$

$$V = n/C = \frac{(5,00 \times 10^{-4})}{(0,025)} = 0,020 \text{ dm}^3 \checkmark \quad (3)$$

6.2) The calculated concentration of the base is higher than the actual concentration. ✓✓ (2)

6.3) $NaOH + HCl \rightarrow NaCl + H_2O$

$$n_{NaOH} = n_{HCl} \checkmark$$

$$n_{NaOH} = CV = (0,525)(2,5 \times 10^{-3}) = 1,31 \times 10^{-3} \text{ mol} \checkmark$$

$$n_{HCl} = CV = (0,355)(7,5 \times 10^{-3}) = 2,66 \times 10^{-3} \text{ mol} \checkmark$$

n_{HCl} is in excess, therefore the $[H_3O^+] > [OH^-] \checkmark$

The solution is acidic. ✓ (5)

QUESTION 7**TOTAL: /25**

- 7.1.1) chemical to electrical.✓✓ (2)
- 7.1.2) The electrode where reduction takes place. ✓✓ (all or nothing) (2)
- 7.1.3) Completing the circuit✓ and maintaining electrical neutrality in the half-cells (by allowing the flow of free ions).✓ (2)
- 7.1.4) a) $n_{e^-} = Q/F \checkmark = 9409/96500 \checkmark = 0,0975 \text{ mol} \checkmark$ (3)
- b) $n_{e^-}/n_X = 0,0975/0,0325 \checkmark = 3$
charge = +3✓ (2)
- c) $Cl_{2(g)} + 2e^- \rightarrow 2Cl_{(aq)}^- \checkmark$
 $X_{(s)} \rightarrow X^{3+}_{(aq)} + 3e^- \checkmark$
 $3Cl_{2(g)} + 2X_{(s)} \checkmark \rightarrow 6Cl_{(aq)}^- + 2X^{3+}_{(aq)} \checkmark$
(Full carry over if 7.1.4b) is incorrect) (4)
- 7.2.1) Concentrated sodium chloride✓ solution.✓ (2)
- 7.2.2) $2Cl_{(aq)}^- \rightarrow Cl_{2(g)} + 2e^- \checkmark \checkmark$ (2)
- 7.2.3) It only allows the Na^+ ion and water to cross hence there is no contamination of the caustic solution ($NaOH_{(aq)}$).✓✓ (2)
- 7.2.4) Hydrogen (gas).✓ (1)
- 7.2.5) Water is a better oxidizing agent than sodium ions.✓✓ Water is preferentially reduced (-0,83 V) compared to the sodium ions (-2,71 V) resulting in hydrogen gas and hydroxide ions being produced.✓ (3)

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) Double bond✓ and hydroxyl group.✓ (2)
- 8.1.3) No✓, It contains a double bond therefore linalool is unsaturated.✓ It contains a hydroxyl group therefore linalool is not a hydrocarbon.✓ (3)
- 8.1.4) Linalool has a higher molecular mass therefore the molecule has more electrons.✓ There is a greater distortion in the electron cloud resulting in stronger London forces.✓ More energy is required to break these stronger London forces hence linalool has a higher boiling point.✓ (3)
- 8.2.1) -1 for each mistake
3-bromo✓-3,7-dimethyl✓octa✓-1,6-diene✓ (4)
- 8.2.2) Compounds having the same molecular formula but different structural formulae.✓✓ (2)
- 8.2.3) Any isomer that has a longest chain of 6-carbons including the double bonds.
Longest chain is 6-carbons including both double bonds.✓✓
Bromine attached to the main chain.✓
Molecular formulae match up.✓ (4)

QUESTION 9

TOTAL: /15

9.1.1) Elimination✓

(1)

9.1.2) Dehydrohalogenation (dehydrobromination)✓

(1)

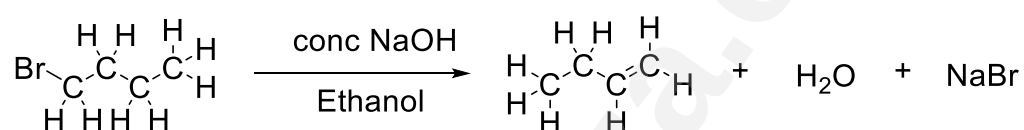
9.1.3) Reactant✓

Product✓

NaCl and H₂O✓

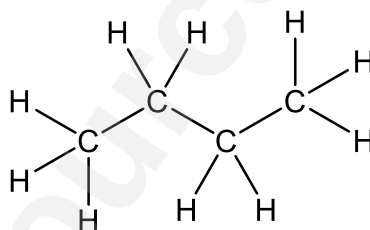
Conditions✓

(4)



9.2) -1 for each mistake

(3)



9.3.1) Addition.✓

(1)

9.3.2) Hydrogenation✓

(1)

9.3.3) $2\text{C}_4\text{H}_{10}\checkmark + 13\text{O}_2\checkmark \rightarrow 8\text{CO}_2\checkmark + 10\text{H}_2\text{O}\checkmark$

(4)