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PRELIMINARY EXAMINATION
8 SEPTEMBER 2020

PHYSICAL SCIENCES: PAPER II

Time: 3 hours

200 marks

MEMORANDUM

QUESTION 1

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

[20]

QUESTION 2

- 2.1 The change in concentration per unit time of either a reactant or product. ✓✓ (2)
- 2.2
- Title ✓
 - Axes labels with units ✓
 - Scales ✓
 - Points plotted correctly ✓✓
 - Line of best fit ✓
- (6)
- 2.3
- Higher gradient ✓
 - Same end volume ✓
(earlier end time)
- (2)
- 2.4
- A higher concentration means there is a greater number of particles per unit volume ✓
 - Thus, there will be more collisions per second ✓
 - and a greater number of effective collisions (ones with the correct orientation and sufficient kinetic energy to overcome the activation energy) per second ✓
 - increasing the reaction rate ✓
- (4)
- 2.5 2.5.1 $270 \pm 5 \text{ s}$ ✓ (1)
- 2.5.2 $\text{Average rate} = \frac{\Delta m}{\Delta t}$ ✓
 $\text{Average rate} = \frac{(152,5 - 150,3)}{(270)}$ ✓✓
Average rate = $8,15 \times 10^{-3} \text{ g} \cdot \text{s}^{-1}$ ✓ (4)
- 2.5.3 The mass in grams of one mole of that substance. ✓✓ (2)
- 2.5.4
- $n_{\text{CO}_2} = \frac{m}{M} = \frac{(2,2)}{(44)}$ ✓ = 0,05 mol
 - $n_{\text{CaCO}_3} = n_{\text{CO}_2}$ ✓ = 0,05 mol
 - $m_{\text{CaCO}_3} = nM = (0,05)(100)$ ✓ = 5 g
 - $\% \text{ purity} = \frac{m_{\text{pure}}}{m_{\text{impure}}} \times 100$ ✓ = $\frac{(5)}{(8)} \times 100$ ✓ = **62,5 %** ✓
- (6)
- 2.6
- Hydrogen bonds are a type of dipole-dipole interactions OR they occur between polar molecules ✓
 - The partially positive hydrogen atom on one H₂O molecule ✓
 - attracts ✓ the lone pair on the partially negative oxygen atom on another H₂O molecule ✓
- (4)

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QUESTION 3

3.1 $[SO_3]_{eq} = \frac{m}{MV} = \frac{(600)}{(80)(0,4)} \checkmark (\text{divide by V}) \checkmark (\text{divide by M}) = 18,75 \text{ mol} \cdot \text{dm}^{-3}$

Concentrations:

R	2SO ₂	+	O ₂	⇌	2SO ₃
I	x		19,1		0
C	-18,75		-9,375		+18,75
E	(x - 18,75)		9,275		18,75

✓

✓

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \checkmark \checkmark$$

$$(280) = \frac{(18,75)^2}{(x-18,75)^2(9,275)} \checkmark$$

$$x = 19,1179$$

$$\therefore n_i(SO_2) = (19,1179)(0,4) = 7,65 \text{ mol} \checkmark$$

OR

$$n(SO_3)_{eq} = \frac{m}{M} = \frac{(600)}{(80)} \checkmark (\text{divide by M}) = 7,5 \text{ mol}$$

Moles:

R	2SO ₂	+	O ₂	⇌	2SO ₃
I	x		7,64		0
C	-7,5		-3,75		+7,5
E	(x - 7,5)		3,89		7,5
C	$\frac{(x-7,5)}{0,4}$		9,725		18,75

✓

✓

✓div by
V

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \checkmark \checkmark$$

$$(280) = \frac{(18,75)^2}{\left(\frac{(x-7,5)}{0,4}\right)^2(9,275)} \checkmark$$

$$x = n_i(SO_2) = 7,65 \text{ mol} \checkmark$$

(8)

- 3.2 One in which mass is conserved inside the system ✓ but energy can enter or leave the system freely ✓.

(2)

- 3.3 3.3.1 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)

- 3.3.2 • Stress: decrease in the concentration of SO₃
 • Le Châtelier's principle predicts the system will respond to counteract the stress and increase the concentration of SO₃ ✓
 • Thus, the forward reaction is (initially) favoured ✓ as it produces SO₃ ✓
 • causing the amount of O₂ at equilibrium to decrease ✓

(4)

- 3.4 3.4.1 • Stress: increase in pressure
• The rates of both the forward and reverse reactions increase ✓ but the rate of the forward reaction increase more as it involves collisions of more gas particles ✓
• Thus, the forward reaction is favoured ✓
• Decreasing the amount of SO_2 at equilibrium ✓ (4)
- 3.4.2 No effect ✓ (1)
- 3.5 • Stress: increase in temperature
• Le Châtelier's principle predicts the system will respond to counteract the stress and decrease the temperature ✓
• Thus, the endothermic reaction will be favoured as it consumes heat ✓
• An increase in oxygen means that the reverse reaction has been favoured ✓
• Meaning the reverse reaction is endothermic and the forward reaction is exothermic ✓ (4)
- 3.6 • SO_2 has dipole-dipole interactions and London forces ✓
• O_2 has London forces only ✓
• SO_2 has more electrons and can therefore form larger induced dipoles ✓, making the London forces in SO_2 much stronger ✓
• Thus, more energy is needed to overcome the intermolecular forces and separate the particles in SO_2 ✓
• resulting in the boiling point of SO_2 being higher (5)
- [30]**

QUESTION 4

4.1 The reaction of a molecular substance with water to produce ions. ✓✓ (2)

4.2 No ✓ they are both neutral salts ✓. (2)

4.3 A base that only dissociates/ionises partially in aqueous solution. ✓✓ (2)

4.4 4.4.1 (The solution of) NaHCO_3 OR baking soda ✓ (1)

4.4.2 $c = \frac{m}{MV}$ ✓
 $c = \frac{(20)}{(84)(0,2)}$ ✓✓
 $c = 1,19 \text{ mol} \cdot \text{dm}^{-3}$ ✓ (4)

4.5 4.5.1 $\text{HCl} + \text{NaHCO}_3 \checkmark \rightarrow \text{NaCl} \checkmark + \text{H}_2\text{O} + \text{CO}_2 \checkmark$ (3)

4.5.2 • $n_a = c_a V_a = (0,155)(0,1) \checkmark = 0,0155 \text{ mol}$
 • $n_b = n_a \checkmark = 0,0155 \text{ mol}$
 • $V_b = \frac{n_b}{c_b} \checkmark = \frac{(0,0155)}{(1,19)} \checkmark = 0,01303 \text{ dm}^3 \checkmark$ (5)

4.6

	Titration 1 (mL)	Titration 2 (mL)	Titration 3 (mL)	Average (mL)
Shriyaa	13,22	12,97	13,51	13,23
Chloë	13,16	13,04	12,95	13,05

4.6.1 Chloë's ✓ (2)

4.6.2 Chloë's ✓ (2)

4.7 4.7.1 • An indicator is needed in a titration in order to determine the equivalence / neutralisation point (OR end point) ✓
 • The reactants are colourless and the indicator will change colour at the appropriate time ✓ (2)

4.7.2 A reaction of an ion ✓ (from a salt) with water ✓. (2)

4.7.3 • Methyl orange ✓
 • $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+ \checkmark$
 • The ammonium ion is the conjugate acid of the weak base $\text{NH}_3 \checkmark$
 • meaning it is also weak, but strong enough to undergo hydrolysis ✓
 • Resulting in excess H_3O^+ ions ✓ (and an acidic solution)
 • (The Cl^- ion is the conjugate base of the strong acid HCl , meaning it is very weak, too weak to undergo hydrolysis.) (5)

[32]

QUESTION 5

- 5.1 The electrode ✓ where reduction occurs ✓. (2)
- 5.2 Pt ✓ (1)
- 5.3 $E_{cell}^0 = E_{cathode}^0 - E_{anode}^0$ ✓
 $(1,51) = (+0,77) - E_{anode}^0$ ✓
 $E_{anode}^0 = -0,74 \text{ V}$ ✓
 Therefore, **X = Cr** ✓ (4)
- 5.4 red: $\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$ ✓
 ox: $\text{Cr} \rightarrow \text{Cr}^{3+} + 3\text{e}^-$ ✓
 overall: **$3\text{Fe}^{3+} + \text{Cr} \rightarrow 3\text{Fe}^{2+} + \text{Cr}^{3+}$** ✓✓ (4)
- 5.5 A substance that accepts electrons. ✓✓ (2)
- 5.6 Fe^{3+} ✓ (1)
- 5.7
- 5.7.1 • The function of the salt bridge is to complete the circuit by maintaining electrical neutrality ✓
 • In the cathode (reduction) half-cell, cations (e.g. K^+) exit the salt bridge ✓ and anions (e.g. NO_3^-) enter the salt bridge ✓
 • In the anode (oxidation) half-cell, anions (NO_3^-) exit the salt bridge ✓ and cations (Cr^{3+}) enter the salt bridge ✓ (5)
- 5.7.2 No effect ✓✓ (2)
- 5.7.3 Decrease ✓✓ (2)
- 5.8 $\text{Cr(s)} \mid \text{Cr}^{3+}(\text{aq}) \mid \mid \text{Fe}^{3+}, \text{Fe}^{2+}(\text{aq}) \mid \text{Pt(s)}$ ✓ ✓(phases) (5)

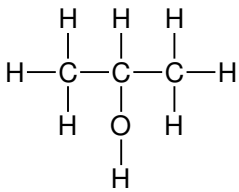
[28]

QUESTION 6

- 6.1 Electroplating ✓ (1)
- 6.2 6.2.1 Cathode ✓ (1)
- 6.2.2 $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$ ✓✓ (2)
- 6.2.3 • Ni^{2+} is a much stronger oxidising agent ✓ than H_2O ✓
• Therefore Ni^{2+} is much more likely to be reduced (OR the reduction of Ni^{2+} is much faster and therefore predominant) ✓ (3)
- 6.3 6.3.1 A substance that can conduct electricity by forming free ions when molten or dissolved in solution. ✓✓ (2)
- 6.3.2 • Nickel is a metal, so has a lattice of positive kernels ✓ and delocalised electrons ✓
• These electrons are delocalised in both solid and liquid phase ✓
• and allow the metal to conduct ✓ (4)
- 6.4 • Any metal that is below Ni (weaker reducing agent) ✓✓
• Cu/Ag/Pt/Au (extra ✓)
• Any of these metals are a weaker reducing agent than Ni ✓ and therefore less likely to be oxidised ✓. (4)

[17]

QUESTION 7

- 7.1  ✓✓ (2)
- 7.2 Hydroxyl group ✓ (1)
- 7.3 A compound having the same molecular formula ✓ but different position of functional group or alkyl substituent (chain branch) ✓. (2)
- 7.4 propan-1-ol ✓✓ (2)
- 7.5 7.5.1 A weak force of attraction between molecules, ions, or atoms of noble gases. ✓✓ (2)
- 7.5.2 London forces, dipole-dipole interactions, hydrogen bonds ✓✓ (2)
- 7.5.3
- Propane has London forces only ✓
 - The predominant intermolecular force in propan-2-ol is hydrogen bonds ✓
 - Hydrogen bonds are stronger than London forces ✓
(extra note that propan-2-ol also has similar strength London forces to propane)
 - More energy is needed to overcome the intermolecular forces and separate the particles in propan-2-ol ✓
 - Resulting in the boiling point of propan-2-ol being higher ✓
- (5)
- 7.6 $2\text{C}_3\text{H}_8\text{O} \checkmark + 9\text{O}_2 \checkmark \rightarrow 6\text{CO}_2 + 8\text{H}_2\text{O} \checkmark$ (both) ✓ (balancing) (4)
- 7.7 2-chloropropane ✓✓ (2)

[22]

QUESTION 8

8.1 8.1.1 Dehydration ✓ (1)

8.1.2 $\text{CH}_3\text{CH}_2\text{CHCH}_2$ ✓✓

OR

$\text{CH}_3-\text{CH}_2-\text{CH}=\text{CH}_2$ (2)

8.1.3 but-1-ene ✓✓ (2)

8.1.4 H_2O ✓ (1)

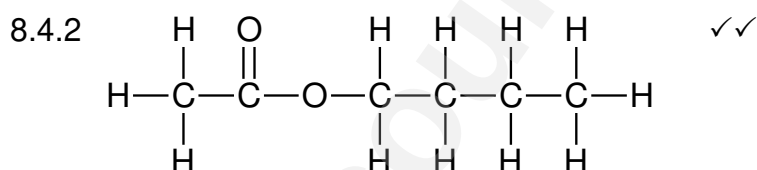
8.2 Addition ✓ (1)

8.3 8.3.1 Cracking ✓✓ (2)

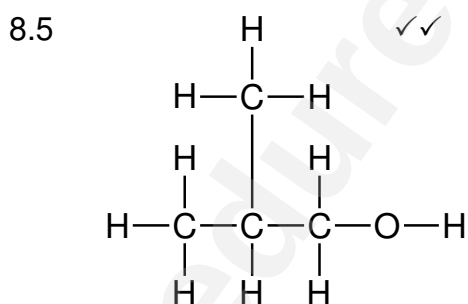
8.3.2 A series of similar compounds which have the same functional group and have the same general formula, in which each member differs from the previous one by a single CH_2 unit. ✓✓ (2)

8.3.3 Alkanes ✓✓ (2)

8.4 8.4.1 Dehydrating agent and acid catalyst ✓ (1)



Butyl ethanoate ✓✓ (4)



(2)
[20]

Total: 200 marks