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Brescia House School

PHYSICAL SCIENCES P2

July 2021

QUESTION 1- MCQ

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

[20]

QUESTION 2 – Chemical Bonding

2.1 Transfer of electrons and the subsequent electrostatic attraction. (2/0) (2)

- 2.2.1 D (2/0) ✓✓
2.2.2 E (2/0) ✓✓
2.2.3 B (2/0) ✓✓
2.2.4 A (2/0) ✓✓
2.2.5 C (2/0) ✓✓

2.3

- Na is a metal with metallic bonds ✓ (OR delocalized electrons and forms a giant metallic lattice structure)
- Ionic bonding between KI and KBr ✓ Strong (electrostatic) attraction between + and – ions. Also forms giant lattice. ✓
- The ionic bonds in the salts are stronger than the metallic bonds in sodium. ✓
- Stronger attraction between K^+ and Br^- than in K^+ and I^- because the difference in electronegativity between K and Br is greater than that of K and I ✓ therefore the charges are greater and therefore more energy is required to break the bonds between the ions ✓ therefore highest BP.

(6)

QUESTION 3: ENERGY CHANGE AND REACTION RATES

(2019 IEB Supplementary exam)

3.1. It is not a closed system ✓ since gas is released. ✓ (2)

3.2. • The $\text{H}_3\text{O}^+ / \text{H}^+$ ions are being consumed/ $[\text{HCl}]$ is decreasing ✓

• decreasing the concentration of H_3O^+ ✓

• The solution becomes less acidic. (2)

3.3.

3.3.1. The net change of chemical potential energy of the system. ✓✓ (2/0) (2)

3.3.2. • The reaction is exothermic ✓

• resulting in the temperature initially increasing (therefore more particles will have the necessary energy to overcome the activation energy) ✓

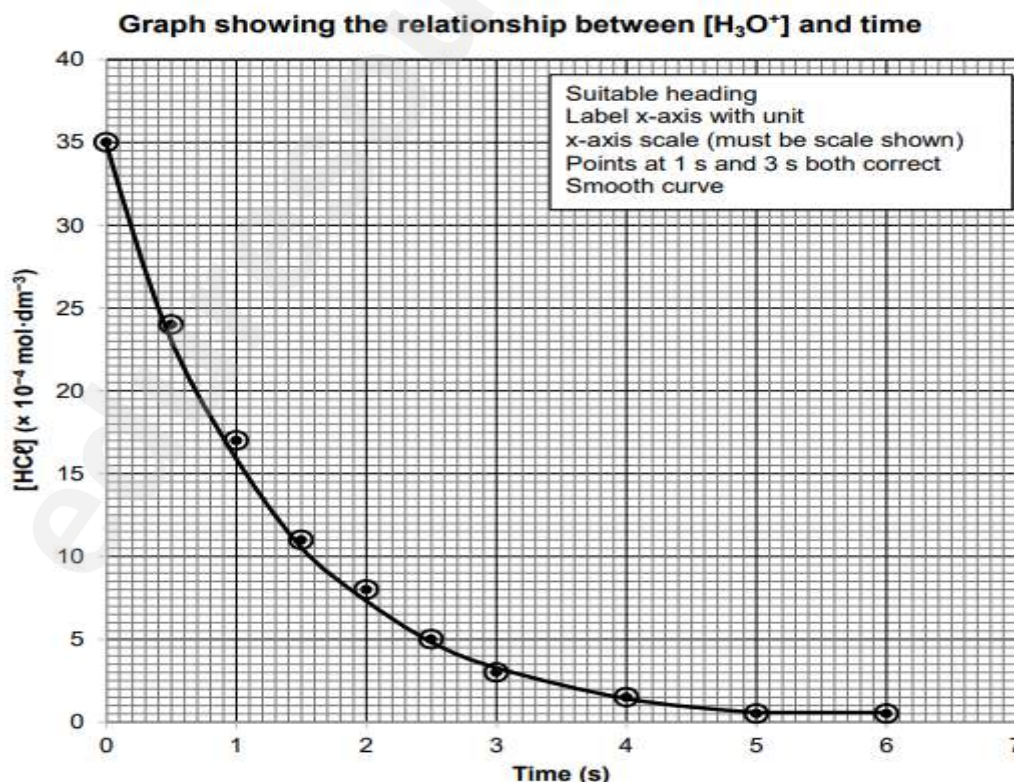
• High conc of HCl molecules will allow for more particles per unit volume and more collisions per unit time. ✓✓ (2)

3.3.3. • As time proceeds, the lump of calcium carbonate becomes smaller, decreasing the surface area of the calcium carbonate ✓

• Fewer particles are exposed to collisions resulting in fewer collisions per second (between the calcium carbonate and acid particles) ✓

• This results in fewer effective collisions per unit time ✓

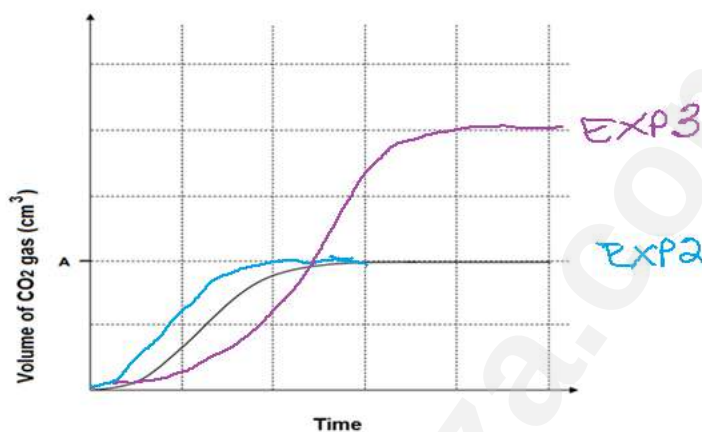
• Leading to a decreasing reaction rate. (given) (4)



3.4.1. Graph (5)

3.4.2 2,5 ($\pm 0,1$ from their graph) ✓ $\times 10^{-4} \text{ mol} \cdot \text{dm}^{-3}$ ✓ (c.o.e from graph) (2)

- 3.5.1.
- $n(\text{CaCO}_3) = \frac{m}{M} = \frac{1,8}{100} = 0,018 \text{ mol} \checkmark$
 - $\text{CaCO}_3 : \text{CO}_2 = 0,018 \text{ mol} \checkmark$
 - $V(\text{CO}_2) = nV_m = (0,018)(22,4) \checkmark = 0,403 \text{ dm}^3 \checkmark \text{ or } 403,2 \text{ cm}^3 \quad (5)$



- 3.5.2.
- Steeper gradient - since HCl has greater conc $\checkmark$
 - same volume since limiting factor is the same. $\checkmark \quad (2)$
- 3.5.3.
- Gradient is less steep since temp is lower – reaction is slower $\checkmark$
 - volume is double since limiting factor is doubled. $\checkmark \quad (2)$

QUESTION 4 CHEMICAL EQUILIBRIUM

4.1.

4.1.1. $\text{COF}_2 \checkmark = 0,5 \text{ mol.dm}^{-3} \checkmark$

$$\text{F}_2 \checkmark = 0,2 \text{ mol.dm}^{-3} \checkmark \quad (4)$$

4.1.2. 7,5 minutes $\checkmark \checkmark$ (5- 10 min) $\checkmark$ (2)

4.1.3. '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' $\checkmark \checkmark$ (2/0) (2)

4.1.4. F_2 was removed. $\checkmark \checkmark$ (2)

4.1.5.

- When the temp decreased the equilibrium shifted to the left/ favoured the forward reaction. $\checkmark$
- Le Chateliers principle states that to accommodate the stress of decreased temp, $\checkmark$
- the exothermic will be favoured. $\checkmark$ In this case the forward reaction,
- so the reverse reaction was endothermic $\checkmark$ (4)

4.2.1 $K_c = \frac{[\text{COCl}_2]}{[\text{CO}][\text{Cl}_2]} \checkmark \checkmark$ (2)

4.2.2 $c(\text{CO}) = \frac{n}{V} = \frac{0,15}{0,5} = 0,3$ Correct method $\checkmark$

$$c(\text{Cl}_2) = \frac{n}{V} = \frac{1}{0,5} = 2$$

$$c(\text{COCl}_2) = \frac{n}{V} = \frac{1,5}{0,5} = 3$$

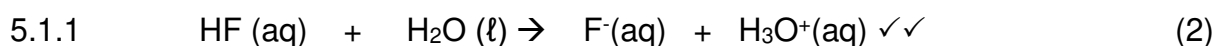
$$K_c = \frac{[\text{COCl}_2]}{[\text{CO}][\text{Cl}_2]} = \frac{[3]}{[0,3][2]} = 5 \checkmark \quad (3)$$

4.2.3 Same temp therefore the same K_c value. $\checkmark$

$$K_c = \frac{[\text{COCl}_2]}{[\text{CO}][\text{Cl}_2]}$$

$$5 = \frac{[\text{COCl}_2]}{[0,1][0,2]} \text{ SUB}$$

$$\text{COCl}_2 = 0,1 \text{ M} \checkmark \checkmark \text{ present.} \quad (3)$$

QUESTION 5 ACIDS AND BASES

5.1.2 Hydrofluoric acid is a weak acid. ✓ (1)

5.1.3 Hydrogen fluoride has a strong covalent bond and the molecule is very polar (– almost ionic). ✓

There are strong hydrogen bonds between the molecules which prevents the formation of hydrogen and fluoride ions when hydrogen fluoride is dissolved in water. There is a stronger attraction between hydrogen end of a molecule and the fluorine end of a different molecule than there is between an HF molecule and a water molecule. ✓

Hydrogen chloride is also bonded covalently but the molecules are not as polar. The intermolecular forces between the molecules are weaker (dipole-dipole forces) and this allows water molecules to accept a hydrogen ion from hydrogen chloride. ✓ (3)

Accepted: Strong acids completely dissociate resulting in more ions in solution. ✓

Weak acids partially dissociate resulting in less ions in solution and more reactant molecules in solution. ✓

The K_a ratio is therefore going to produce a bigger value when there are more ions in solution. ✓

5.2.1 $n(\text{HF}) = c \cdot V = (2,5)(25 \times 10^{-3}) = 0,0625 \text{ mol}$ ✓
 After mixing $[\text{HF}] = n \div V = 0,0625 \div (0,225 + 0,025)$
 $= 0,0625 \div 0,25 = 0,25 \text{ mol} \cdot \text{dm}^{-3}$ ✓ (3)

5.2.2 $[\text{H}_3\text{O}^+] = [\text{F}^-]$ ✓
 $K_a = [\text{H}_3\text{O}^+][\text{F}^-] \div [\text{HF}]$ ✓
 $6,6 \times 10^{-4} = [\text{H}_3\text{O}^+]^2 \div (0,25)$
 $[\text{H}_3\text{O}^+]^2 = (6,6 \times 10^{-4} \times 0,25) = 1,65 \times 10^{-4} \text{ mol} \cdot \text{dm}^{-3}$
 $[\text{H}_3\text{O}^+] = 1,28 \times 10^{-2} \text{ mol} \cdot \text{dm}^{-3} = 0,0128 \text{ mol} \cdot \text{dm}^{-3}$ ✓ (3)

5.3.1 The endpoint of a titration is when the colour of the indicator changes - this point depends on the indicator used. ✓

Equivalent point is a stoichiometric point where the no of moles of acid = base present in the reaction vessel ✓

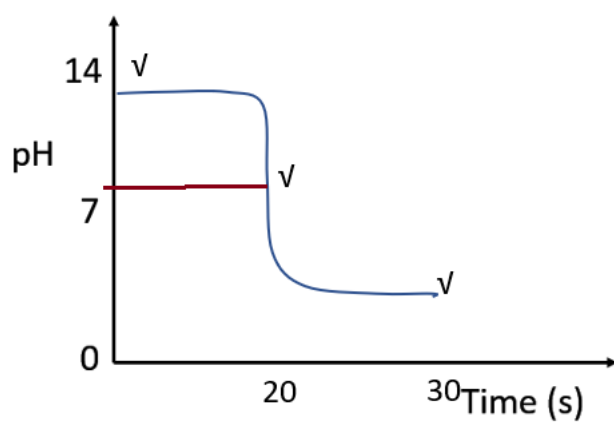
This is not always at the same point. (2)

5.3.2 Basic ✓ The salt KF is formed from a strong base and a weak acid. ✓ (2)

5.3.3 Thymol blue ✓✓ (2)

5.3.4

Graph showing the change in pH of a KOH solution when HF is added



-1 if no labels on axes and heading

v endpoint indicated (4)

QUESTION 6

- 6.1. *electrode at which oxidation occurs* ✓✓ (2/0) (2)
- 6.2. *substance that donates electrons* ✓✓ (2/0) (2)
- 6.3. $\text{Cu} \rightarrow \text{Cu}^{+2} + 2 \text{e}^-$ ✓✓ -1 if double arrows used (2)
- 6.4. $\text{Cl}_2 + 2 \text{e}^- \rightarrow 2 \text{Cl}^-$ ✓✓ (2)
- 6.5. $\text{Cu(s)} / \text{Cu}^{2+}(\text{aq}) (1\text{M}) // \text{Cl}_2(\text{g}) (1\text{atm}) / 2 \text{Cl}^-(\text{aq}) (1\text{M}) / \text{Pt(s)}$ ✓@ 25°C or 298K ✓
 -1 for missing info (4)
- 6.6. $E^\circ_{\text{cell}} = E^\circ_{\text{cat}} - E^\circ_{\text{an}} = 1,36 - (0,34) = 1,02 \text{ V}$ ✓ (3)
- 6.7. .
- 6.7.1. Decrease ✓ (1)
- 6.7.2. Increase ✓ (1)
- 6.7.3. No effect ✓ (1)
- 6.8. No ✓, the product is Cl^- ions ✓ which dissolve in the water ✓ and don't coat the inert Pt electrode (3)
- 6.9. Since this is the anode, oxidation is occurring. So the contamination won't affect the reaction at the anode ✓ BUT the cations will move ✓ through the salt bridge and the presence of Ag^+ ions ✓ will decrease the concentration of the Cl^- ions that are being produced. This will result in a precipitation of AgCl . ✓ (It will take longer for voltmeter reading to decrease to 0V). (4)

QUESTION 7

- 7.1 Electroplating / Refining / electrowinning ✓ (1)
- 7.2 Electrical to Chemical ✓✓ (2)
- 7.3 $m = \frac{\Delta y}{\Delta x} = \frac{500-300}{0,68-0,4} = 714,286 \text{ C} \cdot \text{g}^{-1}$ ✓ (accepted between 680 and 750 dependant on accuracy of points) (3)
- 7.4 $y = mx + c$ since it goes through zero $c = 0$
 $y = mx$
 $Q = F \frac{m}{M}$ therefore $Q = \frac{F}{M} m$ (or $F = \frac{M}{m} Q$)
 Gradient = $\frac{F}{M}$ ✓ (method)
 $F = \text{Gradient} \times M = 714,286 \times 63,5 = 45357.14$ - for copper ions. ✓
 Farads is for electrons:
 $\text{Cu}^{2+} + 2 \text{e}^- \rightarrow \text{Cu(s)}$
 2 : 1
 $45357.14 \times 2 = 90714,28 \text{ C} \cdot \text{mol}^{-1}$ ✓ (3)

QUESTION 8

8.1..

8.1.1. Electrical to chemical ✓✓ (2)

8.1.2. Chloride ions (Cl^-) ✓ (1)8.1.3. $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-$ ✓✓ (2)8.1.4. $2\text{Cl}^- + 2\text{H}_2\text{O} \rightarrow \text{H}_2 + 2\text{OH}^- + \text{Cl}_2$ ✓✓ (2)

8.1.5. $E^\theta = E^\theta$ cathode $-E^\theta$ anode
 $= (-0.83) - (+1.36)$ ✓
 $= -2.19 \text{ V}$ ✓ (2)

8.1.6. E^θ of the oxide of H_2O is more negative than Cl^-
 H_2O is stronger RA ✓ than Cl^- and will be oxidized ✓ (more easily) (2)

8.2.

8.2.1. Pt gauze ✓ (1)

8.2.2. a) $n = \frac{V}{V_o} = \frac{440 \times 10^{-3}}{22,4}$ ✓ = **0,0196 mol** ✓ (3)

b) Mol ratio: Oxygen : Copper
 1 : 2

0,0196 : 0,0392 : ✓

Theoretical mass of Copper = $n.M = (0,0392)(63,5) = 2,4892\text{g}$ ✓

% Yield = $\text{Actual Mass} \div \text{Theoretical Mass} \times 100$

$= 2,5234 \div 2,4892\text{g} \times 100$

$= 101,37\%$ ✓ (3)

c) (Anything practical which indicated that the procedure was not done properly during the collection of the results.) ✓✓

- Not done at STP and the theoretical calcs were based on STP

- Mass deposited was not accurately measured.

- Mass balance was not zeroed.

- Theoretical value was not calculated correctly from the gas.

- Amount of O_2 was not calculated correctly. (2)

QUESTION 9 (ORGANIC CHEMISTRY)

9.1.1 Saturated hydrocarbons: Compounds containing only hydrogen and carbon ✓ with all the bonds between carbon atoms being single bonds. ✓ (2)

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

9.1.3 Chain isomers: Compounds having the same molecular formula but different types ✓ of chain structure i.e. branching. ✓ (2)

9.2.1 carboxyl group ✓✓ (carboxylic acid) ✓ (2)

9.2.2 single bonds / saturated hydrocarbon ✓✓ (alkane) ✓ / bromine atom / halogen atom ✓✓ (not halide / bromide since it is not an ionic bond) (haloalkane ✓) (2)

9.3 $2 \text{C}_5\text{H}_{10} + 15 \text{O}_2 \rightarrow 10 \text{CO}_2 + 10 \text{H}_2\text{O}$

- ✓ CO_2
- ✓ H_2O
- ✓ $+ \text{O}_2$
- ✓ Correctly balanced (4)

9.4 1-bromo-2,2-dimethylpentane
✓ ✓ ✓ (3)

9.5 Compound D has the higher boiling point. ✓

D is propanoic acid, which has two sites at which hydrogen bonding can occur ✓ whereas ethyl methanoate has dipole – dipole forces between molecules. ✓

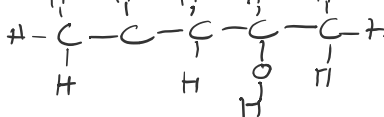
More energy is required to overcome the stronger intermolecular forces in propanoic acid ✓ therefore it has a higher boiling point. (4)

9.6.1 2-bromopentane OR 1-bromopentane ✓✓ NO other products ✓ (3)

9.6.2 hydrohalogenation ✓ (1)

9.7.1 Steam ✓ and a suitable catalyst (H_3PO_4) ✓ (2)

9.7.2 Pentan-2-ol is a positional isomer of pentan-1-ol because they both have the same functional group, the same chain length, but the functional group is placed at a different position in the chain. ✓



9.8.1 esters ✓ (1)

9.8.2 (2)

9.8.3 heptanoic acid ✓ (2)

9.5.4 making perfumes / deodorants / fragrances / making polymers (polyesters) (1)

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