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Grade 12

Date: 28 September 2020

Physical Science PII: Chemistry

Total: 200 marks

Preliminary Examination

Time: 3 hours

Examiner: A. Kamedza

Moderator: I. Krynauw

MARKING GUIDELINES

Question 1

Multiple Choice

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

[10 x 2 = 20 marks]

Question 2

Chemical Bonding

- 2.1.1 Covalent bonds. ✓ (1)
- 2.1.2 Intermolecular force – weak force of attraction between molecules, ions or atoms of a noble gas. ✓✓ (2)
- 2.1.3
 - I₂ is non-polar therefore has London forces. ✓
 - H₂O is polar and has hydrogen bonding forced between molecules. ✓
 - I₂ is a larger molecule/has greater electron density✓ making the London forces **stronger** than the H-bonds in water✓.
 - Therefore more energy is required to overcome the stronger forces in iodine✓ hence it is a solid at room temperature/higher mp. (5)

2.2 KI is very soluble in H_2O , but not very soluble in C_6H_{12} .

2.2.1 *Solvent*.- the liquid✓ in which another substance is dissolved✓ (2)

2.2.2 water✓.(no mark for formula given) (1)

2.2.3 Ion-dipole forces. ✓ ✓ (2)

2.2.4 $-\text{C}_6\text{H}_{12}$. Has London forces✓ which are much weaker✓ than the ionic/electrostatic forces✓ holding the ions in the KI lattice. (3)

OR The strength of the forces holding ions of KI are not similar to those between the C_6H_{12} molecules. ✓ ✓

[16 marks]

Question 3 Energy Change and Rates of Reactions

3.1 *Rate of reaction* - the change in the concentration per unit time in either the reactants or product. ✓✓ (2)

3.2 H_2 gas formed will displace the water in the measuring cylinder✓. The amount of gas formed can be measured✓ per unit time(or every 60 s) ✓. (3)

3.3 How does changing the concentration of the acid affect the rate of reaction?✓✓ (2)

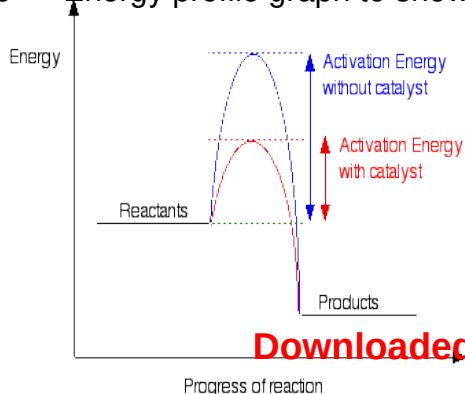
3.4 - surface area/state of the iron✓
- mass/amount of iron✓
- initial temperature of the reactants✓ (3)

3.5 The higher the concentration of the acid, the faster the reaction✓✓ (2)

3.6 - an increase increases the average E_k of particles and frequency of collisions✓
- this results in more particles with sufficient energy($E_k > E_a$) ✓ to collide effectively
- there is an increase in effective collisions per unit time✓
- hence an increase in the rate of reaction✓ (4)

3.7 decrease✓✓ in the rate (2)

3.8 Energy profile graph to show the effect of a catalyst on the reaction (3)



- ✓ shape
- ✓ E_a without catalyst $>$ E_a catalyzed rxn
- ✓ Correctly labeled

[20 marks]

Question 4 Chemical Equilibrium

4.1.1 *Le Chatelier's principle* – when a stress is applied to a system in equilibrium, the equilibrium point will change in order to counteract the stress. ✓✓ (2)

4.1.2 Reverse reaction was favoured. ✓ (1)

4.1.3 Stress: removal of water/increase in $[\text{Cl}^-]$ ✓ (4)
 - The system will counteract the stress by producing more water/removing the chloride ions ✓
 - This results in [reactants] increasing and [products] decreasing ✓
 - hence the solution turns blue due to an increase in $[\text{CoCl}_4]^{2-}(\text{aq})$ ✓

4.1.4 negative ✓✓ / $\Delta H < 0$ (2)

4.2.1 Identify the changes made to the equilibrium mixture at the following times:

a) t_1 – $[\text{N}_2]$ increased/ nitrogen added to the system ✓✓ (2)

b) t_2 – pressure of the system increased/volume of container decreased ✓✓ (2)

c) t_3 – temperature of system was increased ✓ (2)

4.2.2 t_1 ✓ and t_2 ✓. (2)

The engineer now injects 5 mol of N_2 and 5 mol of H_2 into a 5 dm^3 sealed empty container. Equilibrium is reached at 450°C . Upon analysis of the equilibrium mixture, he finds that the mass of NH_3 is 20,4 g.

4.2.3 $n(\text{NH}_3) = m/M = 20,4/17 \checkmark = 1,2 \text{ mol} \checkmark$ (2)

4.2.4 $K_c = [\text{NH}_3]^2 / [\text{N}_2][\text{H}_2]^3 \checkmark$ (2)

4.2.5 Hence, calculate the equilibrium constant (K_c) at 450°C .

	N_2	3H_2	2NH_3
Initial mol	5	5	0
Δmol	-0,6	-1,8	+1,2
Eqm mol	4,4 ✓	3,2 ✓	1,2
[Eqm]	0,88	0,64	0,24 (all ✓)

$K_c = (0,24)^2 / (0,88 \times 0,64^3) \checkmark = 0,25 \checkmark$ (5)

[26 marks]

Question 5 Acids and Bases

- 5.1.1 solution with a known concentration✓
 5.1.2 weak acid is an acid that partially ionizes in solution✓
 5.1.3 Bronsted-Lowry acid – a proton donor✓. (3)
- 5.2 Water of crystallization✓ (1)
- 5.3 $n(\text{oxalic acid}) = c \times v = 0,2 \times 0,5 = 0,1 \text{ mol}$ ✓
 $m(\text{oxalic acid}) = n \times M = 0,1 \times 126 = 12,6 \text{ g}$ ✓ (4)
- 5.4 $(\text{COOH})_2 \cdot 2\text{H}_2\text{O} + 2\text{NaOH} \rightarrow (\text{COONa})_2 + 4 \text{H}_2\text{O}$ ✓ balanced✓ (3)
- 5.5 $n_{\text{base}} = 2n_{\text{acid}}$ ✓
 $n_{\text{acid}} = c \times v = 0,2 \times 0,04 = 0,008 \text{ mol}$ ✓
 $[\text{NaOH}] = n/V = 0,016/0,035 = 0,457 \text{ mol} \cdot \text{dm}^{-3}$. ✓ (4)
- 5.6 Phenolphthalein✓ (5)
 The salt formed in the reaction $(\text{COONa})_2$ hydrolyses in water✓
 $2\text{COO}^- + \text{H}_2\text{O} \rightleftharpoons (\text{COOH})_2 + 2\text{OH}^-$ ✓
 The Na^+ and OH^- ions remain in solution as they form a strong base✓
 resulting in the $[\text{OH}^-]$ increasing making the pH of the solution basic✓
- 5.7 $\text{CH}_3\text{COOH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$ (4)
 Conjugate acid-base pairs: CH_3COOH and CH_3COO^- ✓✓
 H_2O and H_3O^+ ✓✓

[24 marks]**Question 6 Galvanic Cells**

- 6.1 galvanic/voltaic cell – spontaneous reaction✓/converts chemical to electrical energy✓
 electrolytic cell- non-spontaneous reaction✓/converts electrical to chemical energy✓. (2)
- 6.2 Platinum✓ – a conductor✓/that provides a surface for the reaction to occur✓(2)
- 6.3 **Z.-** $\text{CuCl}_2/\text{CuSO}_4$ ✓✓ (2)
- 6.4 - completes the circuit✓ (2)
 - maintains electrical neutrality in the two half-cells. ✓
- 6.5 $\text{Cu}|\text{Cu}^{2+}(\text{aq}) (1 \text{ mol} \cdot \text{dm}^{-3}) \parallel \text{Cl}_2(\text{g}) | \text{Cl}^-(\text{aq}) (1 \text{ mol} \cdot \text{dm}^{-3}) 1 \text{ atm}; 298 \text{ K}$ ✓ (4)
- 6.6.1 $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ ✓✓ (2)
- 6.6.2 $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$ ✓✓ (2)
- 6.6.3 $\text{Cu} + \text{Cl}_2 \rightarrow \text{Cu}^{2+} + 2\text{Cl}^-$ ✓ (2)
- 6.7 $E_{\text{cell}} = E_{\text{cat}} - E_{\text{an}} = 1,36 - 0,34 = 1,02 \text{ V}$. ✓ (4)
- 6.8 Cu ✓✓ is the reducing agent. (2)
- 6.9 As time passes, the [electrolytes] ✓ decreases resulting in the decrease in the rate of reaction✓, cell operating at conditions not standard✓ hence the emf decreases. (3)

[27 marks]

Question 7 Application of Electrochemistry

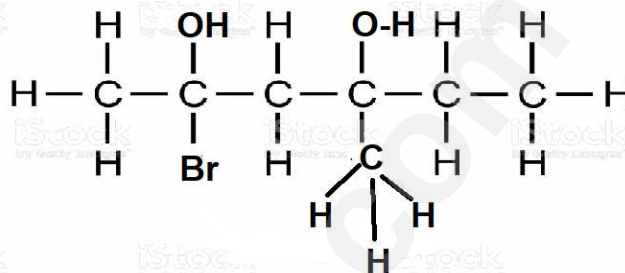
- 7.1 Electrical energy✓ to chemical energy✓. (2)
- 7.2 To lower the melting point✓ of the aluminium oxide reducing the amount of electricity✓ needed and hence the cell operating costs. ✓ (3)
- 7.3.1 $2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$ ✓✓ } x 3 (2)
- 7.3.2 $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$ ✓✓ } x 4 (2)
- 7.3.3 $4\text{Al}^{3+} + 6\text{O}^{2-} \rightarrow 3\text{O}_2 + 4\text{Al}$ ✓. (2)
- 7.4 The oxygen formed at the anode reacts with the graphite electrode✓ to form carbon dioxide✓ causing it to be 'eaten' or 'burnt' away✓.
 $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ ✓ (4)
- 7.5 It will be easy to replace✓ the anodes once they get used up without stopping production✓. This will reduce the cost and/ time taken to produce aluminium✓. (3)
- 7.6 - CO_2 emissions cause the greenhouse effect./Fluorine toxic to plants/animals ✓
 - large amounts of electricity used are produced from burning fossil ✓
 fuels which causes global warming and adds pollutants to the air (2)

[20 marks]**Question 8 Organic Chemistry**

- 8.1 *Functional group* – the center of chemical activity in a molecule✓ (2)
- 8.2.1 $\text{C}_2\text{H}_5\text{OH}$ – hydroxyl group✓ (1)
- 8.2.2 $\text{CH}_3\text{CH}=\text{CHCH}_3$ – carbon to carbon double bond✓ (1)
- 8.3 *Homologous series* - a group of organic compounds with the same general formula and functional group, where each member differs from the previous one by a single $-\text{CH}_2$ unit.✓✓ (2)
- 8.4.1 $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$ – ester✓; ethyl propanoate✓ (2)
- 8.4.2 $\text{CH}_3\text{CHF}=\text{C}(\text{CH}_3)\text{CH}_3$ - haloalkene✓; 3,4-difluoro-2-methylpent-2-ene✓ (2)
- 8.5.1 i) ethane – gas ✓
 ii) hexane – liquid ✓ (2)
- 8.5.2 Hexane has a higher boiling point than ethane.
 They both have London forces✓ as they are non-polar substances.
 Hexane has a longer chain/greater surface area than ethane. ✓
 These London forces increase with chain length/surface area as there are more points for induced dipoles to form. ✓
 More energy is required to overcome the stronger forces. ✓ (4)
- 8.5.3 chain✓ isomers✓. (2)

8.5.4 Ethane has a tetrahedral(3D) structure while ethene has a planar(2D) structure✓. Ethene molecules are tightly packed(stronger forces of attraction between molecules) compared to ethane ✓resulting in a higher melting point for ethene. (2)

8.6 Draw the full structural formula for **2-bromo-4-methylhexan-2,4-diol**. (3)
 2,4-diol✓
 2-bromo-4-methyl✓
 6 carbon atoms in chain ✓



8.7.1 **1-** substitution✓✓
4 - dehydration✓✓. (4)

8.7.2 Compound **B** will have a higher boiling point. ✓ (5)
 B has hydrogen bonds✓ between molecules whereas C has London forces✓.
 Hydrogen bonds are stronger✓ than the London forces and will require a lot more energy for the forces to be overcome✓.

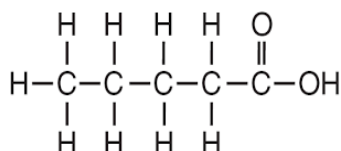
8.7.3 React the two substances with brown bromine✓, ethene immediately decolourises the bromine while ethane will take longer for the reaction to take place. ✓ (4)
 $\text{CH}_2\text{CH}_2 + \text{Br}_2 \rightarrow \text{CH}_2\text{BrCH}_2\text{Br}$ ✓ spontaneous
 $\text{CH}_3\text{CH}_3 + \text{Br}_2 \rightarrow \text{CH}_3\text{CH}_2\text{Br} + \text{HBr}$ ✓ needs UV and a catalyst

8.7.4 (3)

8.7.5 propanoic acid✓ and ethanol✓. (2)

8.7.6 Esterification/condensation✓; acid($\text{H}_2\text{SO}_4/\text{H}_3\text{PO}_4$) catalyst✓. (2)

8.7.7 Pentanoic acid✓. (3)
 Structure✓✓



[46 marks]

Total: 200 marks