BOSWELL-BÈTA

James Boswell Exam

Chemistry VWO

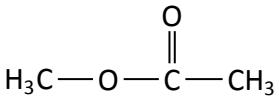
Date:	Example exam 2
Time:	1:00 pm – 4:00 pm (3:00 hours)
Number of questions:	5
Number of subquestions:	23
Number of appendices (hand-in):	1
Total number of points:	85

Important:

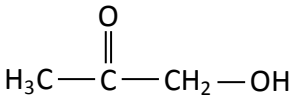
- Write your name on **every sheet of paper** that you hand in.
- Use a separate sheet of paper for each exam question.
- For each question, show how you obtained your answer by means of reasoning and/or calculation. No points will be awarded for an answer without an explanation.
- Write legibly and **in ink/unerasable pen**. Correction fluid and correction tape are not permitted. The use of a pencil is only allowed for drawings.
- You may use the following:
  - A non-graphing calculator.
  - BINAS 5^{th} or 6^{th} edition (either in English or Dutch); please indicate which edition you are using.
  - Drawing equipment, for graphs or structural formulas.
  - An English dictionary.

Question 1: Organic Compounds

The structural formulas of isomeric compounds **A** and **B** are given below:



A



B

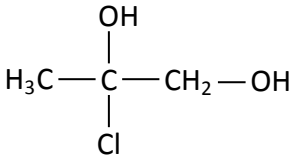
4p. **a.** Provide the systematic (IUPAC) names of both compounds **A** and **B**.

3p. **b.** Explain which of the substances **A** or **B** is more soluble in water.

Compound **A** can be synthesised from an alkanol and an alkanoic acid.

4p. **c.** Using structural formulas, give the reaction in which compound **A** is synthesized.

We react compound **B** with hydrochloric acid, under formation of the following compound:



3p. **d.** Provide the systematic (IUPAC) name of the above compound.

3p. **e.** Reason whether the reaction product will exhibit optical activity.

Question 2: Rodochrosite

Rhodochrosite is a mineral gemstone which is often used in jewels because of its deep dark-reddish color. Rhodochrosite consists mainly of the mineral compound manganese(II)carbonate. The reddish color is being influenced by the contents of mineral iron in the gemstone: the more ferro-iron (Fe^{2+}), the more red its color will be.

At a specific mining site for Rhodochrosite the ferro-iron contents of the gemstone is 1.5 mass percent.

5p. **a.** Calculate the mass percentage manganese in the mineral Rhodochrosite found at this site.

Crystals of Rhodochrosite are only found in alkaline soil (i.e. pH > 7).

5p. **b.** Provide a reason for this. Support your answer using an appropriate reaction equation.

Rhodochrosite is used as source for metallic manganese. Metallic manganese is used as additive to steel to make it more flexible.

Metallic manganese is obtained from Rhodochrosite using electrolysis. After obtaining a solution of $Mn(NO_3)_2$ from Rhodochrosite, electrolysis takes place using a manganese and carbon electrode.

4p. **c.** Make a schematic sketch for the chemical preparation of manganese by electrolysis. In the sketch show which substances the electrodes are made from, and which substances are present in the electrolyte solution. Also indicate which of the electrodes is the negaMve electrode.

At the concentrations used, the electrode potential for the redox-pair Mn^{2+}/Mn is −0.72.

5p. **d.** Give both half reactions and the total reaction of the electrolysis of a solution of $Mn(NO_3)_2$

3p. **e.** Calculate the minimum voltage at which electrolysis will occur. Assume that standard conditions apply at the other electrode.

Question 3: Homogeneous Equilibrium

We consider the following equilibrium: H_2 (g) + I_2 (g) $\rightleftharpoons$ 2 HI (g)

After adding 2 mol H_2 and 2 mol I_2 to a reaction vessel of one liter, equilibrium is obtained under standard conditions ($T = 298$ K en $p = p_0$). At equilibrium the following concentrations are observed: $[H_2] = 1.44$ mol/L, $[I_2] = 1.44$ mol/L and $[HI] = 1.12$ mol/L.

4p. **a.** Give the equation for equilibrium for this reaction, and calculate the equilibrium constant under standard conditions.

When the temperature is increased to $T = 330$ K at equal pressure, the equilibrium constant increases to $K = 1.65$.

3p. **b.** Reason whether the reaction towards the right is either endothermic or exothermic.

In a new reaction vessel of one liter 2 mol H_2 and 2 mol I_2 are brought together at 330 K. The diagram in the Appendix shows the decrease in concentration of $[H_2]$ with time.

4p. **c.** Sketch how the concentration of $[HI]$ changes over time on the diagram in the Appendix.

Question 4: Aqua Regia

Aqua Regia is known to be one of the strongest acids that exist. Its name is indicative as even gold and platinum readily dissolve in Aqua Regia.

Aqua Regia is a mixture of concentrated nitric acid and concentrated hydrochloric acid in ratio 1 : 2. During mixing no change in volume is detected: 1 mL hydrochloric acid, mixed with 2 mL nitric acid results in 3 mL Aqua Regia.

Concentrated nitric acid consists for 86 mass percent of HNO_3 (density 1.51 g/mL); concentrated hydrochloric acid consists for 36 mass percent of HCl (density 1.18 g/mL).

5p. **a.** Show by means of a calculation that the pH of Aqua Regia is pH $= -1.16$. *(note that for concentrated acids the pH can be smaller than 0)*

Gold doesn't dissolve in either concentrated hydrochloric acid or concentrated nitric acid *seperately*; but apparently it does in Aqua Regia.

3p. **b.** Show using BINAS table 48 that gold will not dissolve in a concentrated solution of nitric acid.

Dissolving gold in Aqua Regia is proceeds via a two step process:

1. $Au\ (s) + 3\ NO_3^-\ (aq) + 6\ H^+\ (aq) \rightleftharpoons Au^{3+}\ (aq) + 3\ NO_2\ (g) + 3\ H_2O\ (l)$
2. $Au^{3+}\ (aq) + 4\ Cl^-\ (aq) \rightleftharpoons [AuCl_4]^-\ (aq)$

The equilibrium in reaction (2) almost runs to completion.

3p. **c.** Reason that, based on the two reaction steps given above, gold will readily dissolve in Aqua Regia.

A laboratory assistant is given the task of determining the gold content in a certain type of gold ore using Aqua Regia. The laboratory assistant uses the following procedure:

- He weighs 24.2 g of ore, which he subsequently washes with concentrated hydrochloric acid. The remaining metal, of which he assumes consists of only gold, he quantitatively transfers into a test tube.
- Using a burette, he subsequently slowly adds Aqua Regia until he observes that all gold has dissolved. This happens after adding 11.4 mLAqua Regia. He assumes that all gold will now exist as $[AuCl_4]^-$ and that no free chloride ions will be present.

3p. **d.** Reason whether in this titration an acid-base indicator could have been used. *(Hint: consider the mole ratios in the total reaction.)*

5p. **e.** Calculate the gold content of the ore in mass percentage.

Question 5: Kevlar

Kevlar is a polymer known for its relative high tensile strength: it is far stronger than steel and much more flexible. Because of these properties Kevlar is widely applied, among which in bulletproof vests.

Kevlar is a polyamide that is made from benzene-1,4-dicarboxylic acid and benzene-1,4-diamine.

4p. **a.** Draw the structural formulas of benzene-1,4-dicarboxylic acid and benzene-1,4-diamine.

2p. **b.** Explain whether the formation of Kevlar involves either addition or condensation polymerisation reactions.

5p. **c.** Draw part of the middle of a Kevlar polymer chain. Limit your drawing to three monomer units.

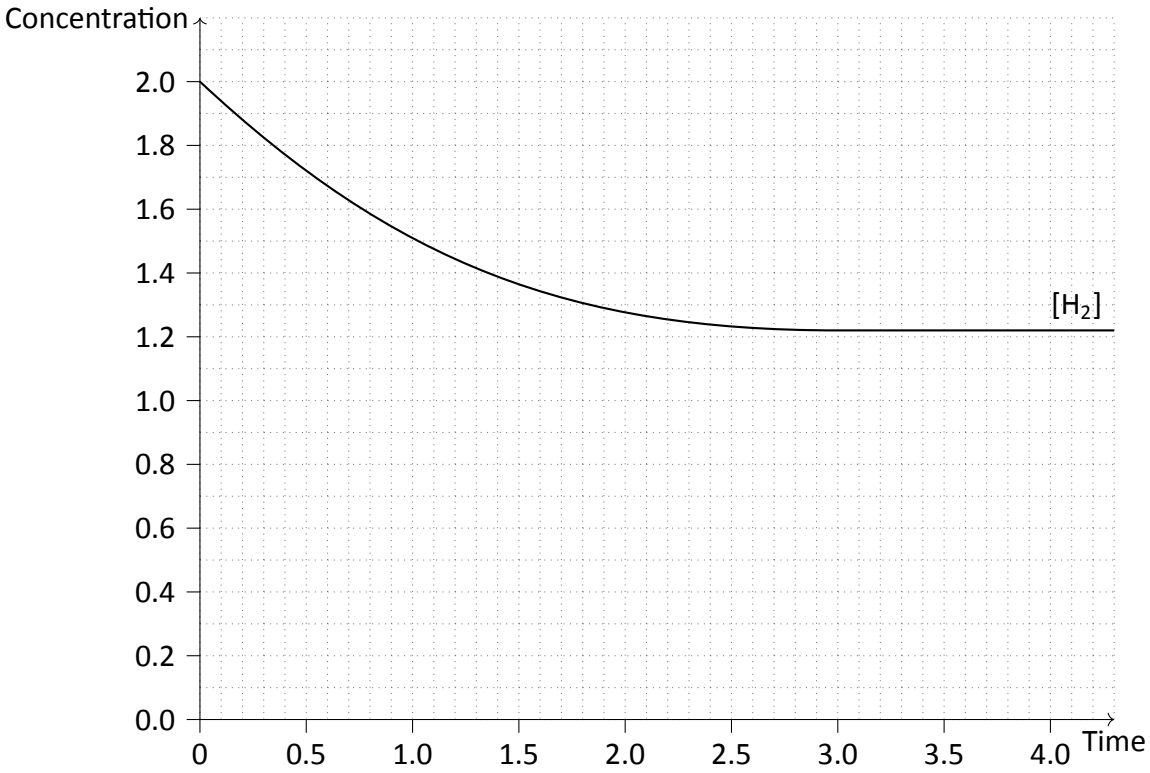
2p. **d.** Explain whether Kevlar will be a thermoplastic or thermosetting material.

The material strength of Kevlar is obtained from the interactions between the polymer chains.

3p. **e.** Explain which interactions between polymer chains of Kevlar contribute to its strength.

Candidate name: _____

Question 3.c



DO NOT FORGET TO HAND IN THIS APPENDIX