**Task C1 – 19 points**

**Question C1.1**

How many carbon atoms are in a structural unit of hyaluronic acid?

|  |
| --- |
| 14 |

*0.5 points*

Calculate the degree of polymerization of hyaluronic acid chain weighting 150 kDa (kilodalton).

|  |  |  |
| --- | --- | --- |
| (C14H21NO11)*n*  *0.5 points*  *M* = 379  *0.25 points*  *n* = 150000 / 379 = 396  *0.25 points* | | |
| *n*(150 kDa polymer): | 396 |

***In total 1.5 points for C1.1.***

*Viscosity measurement*

**Question C1.2** Speed of fall of the steel ball

|  |  |  |  |
| --- | --- | --- | --- |
| *M* [kDa] | *t* [s] | *l* [mm] | *v* [mm∙s−1] |
|  |  |  | xxx |
|  |  |  | xxx |
|  |  |  | xxx |
|  |  |  | xxx |

*0.25 points for each correctly calculated speed.*

***In total 1 point for C1.2.***

**Question C1.3** Calculation of viscosity

|  |
| --- |
| gravity = resistance + buoyancy  *1 point*  6*π* ∙*η* ∙ *r* ∙ *v* = (Δ*ρ* ∙ *V* ∙ *g*)  *η* = (2 ∙ Δ*ρ* ∙ *π* ∙ *r*2 ∙ *g) / (*9 ∙ *v*)  *2 points*  If Δ*ρ* is given in kg∙mm−3, then viscosity is in required N∙s∙mm−2.  *0.5 points* |

Viscosity of solutions

|  |  |  |
| --- | --- | --- |
| *M* [kDa] | *η* [N∙s∙mm−2] | *η* [Pa∙s] |
|  | xxx | xxx |
|  | xxx | xxx |
|  | xxx | xxx |
|  | xxx | xxx |

*0.5 points for each correctly calculated viscosity in N∙s∙mm−2.*

*0.25 points for each correctly calculated viscosity in Pa∙s (differs from the previous by 106 factor).*

***In total 6.5 points for C1.3.***

**Question C1.4** Empirical coefficients

|  |  |
| --- | --- |
| *K* = | xxx |
| *α* = | xxx |

*1 point for correct linearization in Graph: logη = logK + α∙logM*

*(0.25 points penalty for non-well-looking Graph)*

*1 point for reasonably determined K, 1 point for reasonably determined α.*

***In total 3 points for C1.4.***

*Polymer degradation*

**Question C1.5** Times of ball fall in individual mixtures

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Time of ball fall (measured by the second stopwatches) [s] | | | | |
| Total time (according to the first stopwatches) [min] | mixture a | mixture b | mixture c | mixture d | mixture e |
|  | *5∙*xxx | *5∙*xxx | *5∙*xxx | *5∙*xxx | *5∙*xxx |

*0.2 points for each experimental data.*

***In total 5 points for C1.5.***

**Question C1.6** What is probable mechanism of polymer degradation? Mark the right answer.

|  |  |  |
| --- | --- | --- |
| ~~a) electrophilic~~ | ~~b) nucleophilic~~ | c) radical |

*1 point*

Explanation of your choice

|  |
| --- |
| Catalytic role of Fe2+/Fe3+ on peroxide decomposition – formation of HO∙ and HOO∙ radicals (Fenton reactions), which decompose polymer. |

*1 point*

***In total 2 points for C1.6.***

**Task C2 – 16 points**

**Question C2.1**

Value of p*K*A of unsubstituted organic acids is ca 4.8 [e.g. p*K*A(acetic acid) = 4.76, p*K*A(propionic acid) = 4.88, p*K*A(butyric acid) = 4.81].

Explain reasons, why p*K*A of d-glucuronic acid differs from those of mentioned organic acids.

|  |
| --- |
| p*K*A should be lower because of electron-withdrawing effect of the neighbouring oxygen atoms (OH groups).  *1 point* |

***In total 1 point for C2.1.***

**Question C2.2**

In what pH region will solution of acetic acid work as the best buffer? Mark the right answer.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ~~a) pH 0–2~~ | ~~b) pH 2–4~~ | c) pH 4–6 | ~~d) pH 6–8~~ | ~~e) pH 8–10~~ |

***In total 1 point for C2.2.***

**Question C2.3**

In what pH region will lie pH of the 0.1m solution of sodium acetate? Mark the right answer.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ~~a) pH 2–4~~ | ~~b) pH 4–6~~ | ~~c) pH 6–8~~ | d) pH 8–10 | ~~e) 10–12~~ |

***In total 1 point for C2.3.***

***Question C2.4***

*Factorization of stock solution of NaOH*

Consumed volumes of NaOH in factorization

|  |  |  |  |
| --- | --- | --- | --- |
| *V*1 [ml] | *V*2 [ml] | *V*3 [ml] | accepted value of  *V* [ml] |
|  |  |  | xxx |

*Difference from “master value” obtained by organizers is marked.*

*ΔV ≤ 0.3 ml: 3 points*

*0.3 ml ≤ ΔV ≤ 0.9 ml: 4.5 – 5∙ΔV points*

*0.9 ml < ΔV: 0 points*

***Maximum 3 points for C2.4.***

**Question C2.5** Concentration of stock solution of NaOH

|  |  |  |
| --- | --- | --- |
| *n*(NaOH) = 2∙*n*(oxal)  *c*(NaOH) = 2∙*c*(oxal)∙*V*(oxal) / *V*(NaOH)  *0.5 points for correct procedure.*  *0.5 point for correct numerics.* | | |
| *c*(NaOH): | xxx mol∙dm−3 |

***In total 1 point for C2.5.***

*Determination of concentration of d-glucuronic acid*

**Question C2.6** Consumed volumes of NaOH in titrations of d-glucuronic acid

|  |  |  |  |
| --- | --- | --- | --- |
| *V*1 [ml] | *V*2 [ml] | *V*3 [ml] | accepted value of  *V* [ml] |
|  |  |  | xxx |

*Difference from “master value” obtained by organizers is marked.*

*ΔV ≤ 0.2 ml: 3 points*

*0.2 ml ≤ ΔV ≤ 0.5 ml: 5 – 10∙ΔV points*

*0.5 ml < ΔV: 0 points*

***Maximum 3 points for C2.6.***

**Question C2.7** Concentration of d-glucuronic acid

|  |  |  |
| --- | --- | --- |
| *n*(ga) = *n*(NaOH)  *c*(ga) = *c*(NaOH)∙*V*(NaOH) / *V*(ga)  *0.5 points for correct procedure.*  *0.5 point for correct numerics.* | | |
| *c*(d-glucuronic acid) = | xxx mol∙dm−3 |

***In total 1 point for C2.7.***

**Question C2.8**

Chosen volume of NaOH

|  |  |
| --- | --- |
| *V*(NaOH) = | xxx ml |

*1 point for one-half value of consumed NaOH in titration.*

pH values of prepared solutions

|  |  |
| --- | --- |
| pH1 | pH2 |
| xxx | xxx |

*0.5 points for each measured value.*

Determined p*K*A of d-glucuronic acid

|  |  |
| --- | --- |
| p*K*A(d-glucuronic acid) = | xxx |

*Difference from “master value” obtained by organizers is marked.*

*Δ pKA ≤ 0.3: 3 points*

*0.3 ≤ Δ pKA ≤ 0.6: 6 – 10∙Δ pKA points*

*0.6 < Δ pKA: 0 points*

***In total 5 points for C2.8.***

**Task C3 – 15 points**

**Question C3.1**

What is energy of photon of light used for spectrophotometric measurement (585 nm)? Write the value as frequency (in Hz) as well as wavenumber (in cm−1).

|  |  |  |  |
| --- | --- | --- | --- |
| *ν* = *c* / *λ*  = 1 / *λ*  *0.5 for each correct formula.*  *0.5 for each correct numerics.* | | | |
| *ν*(585 nm) = | 5.12∙10−14 Hz | (585 nm) = | 17100 cm−1 |

***In total 2 points for C3.1.***

**Question C3.2**

Absorbance of prepared solutions

|  |  |  |
| --- | --- | --- |
| solution | *c*(*N*-acetyl-d-glucosamine)  [mol∙dm−3] | *A*(585 nm) |
| standard 0 | 0 | xxx |
| standard 1 | 2.5∙10−4 | xxx |
| standard 2 | 5.0∙10−4 | xxx |
| standard 3 | 7.5∙10−4 | xxx |
| standard 4 | 1.00∙10−3 | xxx |
| unknown sample | – | xxx |

*0.5 points for each correct concentration of the standards.*

*Maximum 6.5 b for linearity of the calibration curve: the best value of 1.3∙n∙R2 from linear fit performed with students’ data (n = number of points included in the regression, lower number than all 5 points takes place when R2 is lower than 0.8).*

*(0.25 points penalty for non-well-looking Graph)*

***In total 8 points for C3.2.***

**Question C3.3**

|  |  |
| --- | --- |
| *c*(unknown sample): | xxx mol∙dm−3 |

*Difference from “master value” given by organizers is marked.*

*Δc ≤ 0.5 mm: 5 points*

*0.5 mm ≤ Δc ≤ 2.5 mm: 6.25 – 2.5∙Δc points*

*2.5 mm < Δc: 0 points*

***Maximum 5 points for C3.3.***